Chapter 5
Physical, Mechanical and Cultural Control of Vegetable Insects

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Abstract Pest control is as old as agriculture, as there has always been a need to keep crops free from pests in order to maximize food production. Historically, mechanical and cultural practices were the major methods used by farmers to prevent crop losses. Prior to the emergence of the plant protection sciences farmers evolved many cultural practices through trial and error experiences to minimize the damage caused by insect pests. In recent years pesticides have become the major method of pest control. Due to the problems related to the use of pesticides physical, mechanical and cultural controls serve as an alternative to the use of pesticides in an integrated pest management approach. Physical methods consist of thermal methods and electromagnetic radiation. Mechanical control refers to measures that involve the operation of machinery or manual operations such as the hand picking of insects from plants. Cultural control consists of modifications of standard agricultural practices such as time of planting and crop rotation. Examples of physical, mechanical and cultural control methods employed in the management of tropical vegetable pests and diseases are herein discussed.

Keywords Electromagnetic radiation • Crop rotation • Trap cropping • Technology transfer

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R. Muniappan, E.A. Heinrichs (eds.), *Integrated Pest Management of Tropical Vegetable Crops*, DOI 10.1007/978-94-024-0924-6_5

Introduction

Vegetables are important sources of vitamins, minerals, plant proteins and other elements which are essential for human health throughout the world (Fowler 2011). Despite the importance of vegetables, the cultivation of vegetables is constrained by biotic stresses including insect pests. Significant losses in quantity and quality caused by insect pests have been reported by several workers. The use of insecticides is the most common component of insect pest management in vegetables. However, prolonged use of several synthetic insecticides caused development of heritable resistance to insecticides in more than 540 species of insect pests (Metcalf et al.1994). In addition, the resurgence and outbreak of secondary pests, harmful effects on non-target organisms and potential effects of pesticides on human health and the environment have been widely reported and documented (Metcalf and Luckmann 1994; Novartis 1997). In order to overcome these problems interest has been revived in the search for alternative and sustainable pest control methods. Integrated Pest Management (IPM) is the integration of two or more pest control tactics into one program and is considered an environmentally acceptable and economically profitable means of managing insect pests. Physical, mechanical and cultural control methods hold promise from pre- to post-harvest situations of the crop (Vincent et al. 2003). This chapter emphasizes the physical, mechanical and cultural control of insect pests on tropical vegetables.

The information on passive and active methods of physical controls by Charles Vincent, Guy Hallman, Bernard Panneton and Francis Fleurat-Lessard is a classic and well summarized in the 2003 Annual Review of Entomology titled "Management of Agricultural Insects with Physical Control Methods" and modified and supplemented with cultural control methods (Metcalf et al.1962, 1994; Metcalf and Luckmann 1994; Pfadt 1971; Ross 1967; Sorensen 2000). These references together provide a total and complementary approach to insect pest control and management on vegetable and related crops (Sorensen and Baker 1994). The Vincent et al. 2003 review (Vincent and Chagnon 2000) complemented earlier work of Banks (1976), Hallman and Denlinger (1998), Oseto (2000), and Vincent et al. (2001) and offered a critical assessment of physical controls with the objective of formulating recommendations for further research and applications. This chapter provides an integrated approach and summary of the current literature on physical, mechanical and cultural control methods and how they are used in vegetable production. It also offers some expanded opportunities in IPM in vegetables and how they and others might be used in developed and in developing tropical ecosystems (Rabb and Guthrie 1970; Sorensen 1977, 2008).

Physical Control

Physical methods aim to reduce pest populations by using devices that physically affect pests or affect their physical environment (Dhaliwal and Arora 1996). Physical control methods modify the physical environment of insect pests and thus minimize their threat to agricultural crops. The result ranges from agitation to death of these pest insects, as many physical control methods affect the physiological and behavioral processes of insect pests. Physical control methods give immediate and effective control of insect pests from emergence to post harvest (Hallman 2000) and the methods are popular and accepted by farmers. Physical control consists of thermal methods and electromagnetic radiation.

Thermal Methods

(i) **Temperature** (both high (Fleurat-Lessard and Le Torc'h 2001) and low temperatures (Fields 2001)) can be effective to reduce the population of insect pests and is used postharvest to slow degradation of produce caused by physiological processes, pathogens, and insect pests. In insect control both temperature and rate of changes and duration of exposure must be considered (Duchesne et al. 2001).

(ii) **Cold storage**: The oldest and most widely used quarantine treatment is storage of fresh commodities of vegetables and others at −0.6° to 3.3 °C for 7–90 days, depending on nature of the produce, insect pest status and temperature (APHIS 1998).

(iii) **Heated air**: Quarantine treatments using heated air were first used against the Mediterranean fruit fly infestation in Florida in1929. These treatments expose commodities to air at temperatures in the range of 43–52 °C from a few to many hours. Preconditioning vegetables with a mild heat treatment prior pesticide treatment reduces damage to commodities (Hallman 2000; Hara et al.1997).

(iv) **Hot-water immersion**: Immersion at 43–55 °C ranging from a few minutes to a few hours is used to kill a variety of arthropods and nematodes on plant-propagative materials (yam, colocasia, etc.). Hot-water immersion is simple, economical, and rapid method for disinfestation of plant materials from insect pests. A variation with hot-water immersion is a hot-water drench, which appears to cause less damage to vegetables than total immersion (Bollen and DelaRue 1999).

(v) **Steaming**: It affects insect legs when exposed to temperatures from 68 to75 °C. Leg muscles are inactivated by dipping insects from 0.2 to 0.4 s in hot water. Steaming in laboratory and field conditions impaired locomotion of only 35 % of Colorado potato beetle adults when used at the maximum acceptable temperature for the potato plant (Pelletier et al. 1998).

Electromagnetic Radiation

Electromagnetic radiation energy is absorbed by ionizing atoms or by inducing vibration of charged particles within the matter thus increasing temperature because of internal frictions (Lewandowski 2001).

(i) **Irradiation**: Ionizing radiation provided by cobalt-60, cesium-137, or linear accelerators are an effective commercial quarantine treatment (Hallman 2000). Radiation is effective by providing sterility at doses tolerated by fresh commodities.

(ii) **Reproductive**: Reproductive control in insects has been most effective where it has been developed and used against flies and is receiving much attention with moths, beetles and weevils. This method renders males sterile but still active. Rearing and releasing these gamma radiated males, in greater numbers than exist in the natural population, is extremely expensive. A group of organic compounds called chemosterilants also produce varying degrees of sterilization in insects and continues to receive attention. Efforts to manipulate the sex determining apparatus of a species so that few females are produced are a part of genetic engineering (Pfadt 1971; Ross 1967).

(iii) **Radio frequency heating**: The radio frequency (RF) part of the electromagnetic spectrum produces non ionizing waves which transfer energy faster and more efficiently than heated air or water treatments. Although RF energy kills insects and much research has been conducted on its effects (Hallman and Sharp 1994; Halverson et al. 1997; Nelson 1995), it has rarely been used on a commercial scale.

Mechanical Control

Mechanical control refers to measures that involve the operation of machinery or manual operations. It is the management and control of pests using means such as fences, barriers or traps. It results in the reduction of or suppression of insect populations.

Barriers may be any living or non-living materials used for restricting pest movement or to delineate a confined space. They are compatible with other control methods (Boiteau and Vernon 2001) and are degradable or non-degradable barriers that can be dismantled and possibly reused to help lower cost. But establishing barriers incur a cost for labor and storage.

An obvious physical barrier is a glass, plastic or screened green house. An additional partial barrier is the use of plastic in raised beds and in low and high tunnels where the ends are open. Nursery beds covered with polythene sheets of 45 gauged (0.45 mm) thickness for the period of 3–4 weeks significantly reduce the incidence of soil borne insect pests and their damage. Row covers have also been used to protect plants from direct insect pest attack or from vectoring plant diseases (Sorensen 1978–80b). All of these methods protect plants from insect pests by prevention or delay of insect pest attack and subsequent economic damage.

Screening of green houses or plant beds will keep out some insect pests. Of course they can also keep insect pests in the screen housed along with some natural enemies (parasitoids and predators) should they be introduced (Sorensen 1991, 1997). Individual plants or fruit and plant beds can be screened with thin cloth or netting. Sticky bands around small plants or collars around plants or chips under melons, hot kaps, and shingles on soil around plants and use of other devices can provide hiding places for pest insects and attract them where they can be crushed. This prevents or slows down insect establishment and economic damage (Sorensen 1991, 1996, 1997). The destruction of insects or egg masses by hand is practical where cheap labor is available and where the insect or eggs are large, not too active or occur in relatively restricted or small areas. Mechanical devices such as hopper dozers, hopper catches, aphid dozers, fly traps, moth traps maggot traps, light traps, electric traps and entoleters can be used with some to total effectiveness.

(i) **Hand collection and destruction**: Handpicking is the most ancient method of mechanical control of egg masses, larvae and adults of several insect pests. This includes the tomato fruit borer (*Helicoverpa armigera*) infested plant materials and egg masses of *Spodoptera litura* on leaf surfaces and reduces further incidence and damage.
(ii) **Cleaning**: Cleaning is a most common pre and post-harvest treatment and as a quarantine treatment, is followed by inspection and by another treatment. Soapy water and wax treatment were used against the false spider mite in Chile. It consists of immersion of cherimoyas (*Annona cherimola*) and limes in soapy water for 20 s, a rinse and then immersion in a wax coating (APHIS 1998).
(iii) **Sound**: Sounds at frequencies <20Hz can be defined as infra sound, and ultra sound at frequencies higher (>∼16 kHz) than human audibility (Sorensen 2008). All insects contain microscopic gas bodies that can oscillate under the influence of ultra sound and abnormal development of *Drosophila melanogaster* resulted from these oscillations (WHO 1982). As ultra sound transmits well through water, its use in postharvest, while produce is being washed by immersion in water, was tried on asparagus spears for thrips with negative results (Van Epenhuijsen et al. 1997).
(iv) **Pneumatic**: Insect pests can be dislodged from plants using blown or aspirated air, but blown insects must be collected and destroyed (Khelifi et al. 2001). Success has been reported on Colorado potato beetle (Lacasse et al. 2001; Vincent and Boiteau 2001), leaf miners on celery, and whitefly on melons (Vincent and Boiteau 2001).

Trenches or Ditches

Trenches to intercept walking insects such as the chinch bug were implemented as early as 1895 (Metcalf et al. 1962; Ross 1967). Studies conducted 100 years later on potato in the northern temperate zone support the effective use of V-shaped ditches, either plain or lined with plastic. These ditches can retain overwintering populations of adult Colorado potato beetles (Ferro 1996; Metcalf et al. 1962; Misener et al. 1993). Crawling hordes of insects can be stopped with deep ditches around fields toward which they are walking. Use of barrier lines of certain heavy-bodied oils poured along the ground and low fences of sheet metal, and V-shaped ditches to control some beetles or weevils for a limited period of movement have been somewhat effective (Pfadt 1971; Ross 1967).

Fences

Fencing has been effective for excluding low-flying insects (e.g., anthomyiids and thrips) from annual crops where few insecticides are registered and the crop value is high (e.g., onion and cole crops) (Boiteau and Vernon 2001). In tomato, the use of 100 mesh nylon nets in nursery prevents the entry of whiteflies *Bemisia tabaci* and their transmission of leaf curl disease.

Organic Mulch

Organic growers have had success with straw mulch as it indirectly affects the Colorado potato beetle population and significantly reduces the damage (Ferro 1996; Yepsen 1977) by favoring several species of egg and larval predators. The use of mulch must be prior to peak emergence of moths (Sorensen 1972–82, 2005a, b). Proper mulching and irrigation helps to reduce population buildup of major insect and mite pests in vegetable cultivation (Srinivasan 2016).

Mulches from Artificial Materials

Paper or plastic sheets or aluminized films can be used for mulching and provide insect control directly or indirectly by preventing feeding by insect vectors of several plant viruses. Plastic mulches of different colors modify the spectrum of incident light and alter the behavior of insects and confuse the insects in flight and landing. Thrips are attracted to blue, black, and white (Sorensen 2002), aphids to yellow and (Black 1980; Csizinsky et al. 1990) and *Spodoptera litura* to blue. Aluminized materials can attract some insects and repel others (Bégin et al. 2001; Jackson et al. 1998). These are sometimes called a push or pull method of insect management. UV-reflective mulches have been used in the management of insect pests on pepper and tomato (Kring and Schuster 1992). Artificial mulches also interfere in the growth and development of weeds, insect pests, plant diseases and nematodes, and also enhance yields (Bégin et al. 2001; Vincent et al. 2001).

Aluminum reflective strips or paint on the shoulder beds of black plastic provide effective management of aphid vectored *Watermelon mosaic virus II*. The virus development was delayed and fruit symptoms appeared several weeks later and bountiful harvests of clean fruit were obtained. The aluminum strip or paint/black plastic provided satisfactory control until the squash plant covered the entire bed (Sorensen 1978–80b).

Trapping

As a management tool, perimeter trapping has been successful in intercepting flying dipterans. Monitoring and mass trapping with sticky traps with protein bait of different colors has been effective for trapping dipteran adults on cabbage (Sorensen and Baker 1994). Seed corn maggot adults and cucumber beetles have been monitored and captured in large numbers on cucumbers with some success. Aphids, leafminer flies, thrips and other soft bodied insects and natural enemies have also been collected on sticky traps (Fig. 5.1). Tedders black pyramidal traps have been effective in monitoring pecan weevil emergence for the purpose of timing sprays and to provide some mass trapping action (Sorensen 1996). Yellow sticky cups have been inverted and staked to monitor and forecast several insect pests (aphids, flea beetles, thrips wireworm adults, Japanese beetles) and some of their natural enemies on sweet potato (Fig. 5.2) (Sorensen 2002, 2008). Sticky traps, treated with various insecticides, placed in the field overnight to collect tomato pinworm moths, and then brought back to the lab, have been used to determine insecticide resistance levels (Schuster et al. 1996). Use of yellow pan/sticky traps @ 10 per ha help to reduce the sucking pest populations. Installation of sex pheromone traps @ 12 per ha can be used to monitor the population of *H. armigera*, *S. litura* and *Earias* spp. (Hamed and Nadeem 2010).

Fig. 5.1 Sticky traps with soft bodied insects

Fig. 5.2 Sweet potato weevil trap

Oils, Soaps, and Surfactants

Oils and soaps (2 %) have been used over many years to control scale insects, aphids, mites and borer eggs. MPede is a commercial soap that is widely used against soft bodied insects of several crops that require frequent spray with a day pre-harvest interval between last application and harvest (Sorensen 1991, 1997; Sorensen and Baker 1994). It is here, and with organic production of vegetables, that safe products like MPede and others are being developed for niche markets. These oils affect the respiratory system of adult insects and mites or their immature stages, particularly eggs. In some cases they act as an oviposition deterrent. Arthropods affected include mites, scale insects, mealybugs, psyllids, aphids, leafhoppers and some lepidopteran eggs. SilwetL-77 is an organo-silicone molecule that has insecticide effects and has activity against the diamond back moth on crucifers (Gauvrit and Cabanne 2002; Shapiro et al. 1998).

Cultural Control

Simple modifications of a pest's environment or habitat often prove to be effective methods of pest control. As a group, these tactics are usually known as cultural control practices because they frequently involve variations of standard agricultural practices. Cultural control is the reduction of insect pest populations on crops by use of agricultural practices which makes the environment unfavorable for insect pests

(Metcalf et al. 1962; Pfadt 1971; Sorensen 1977, 1987, 2000; Westcott 1964). Cultural control measures differ from physical or mechanical control in generally involving the use of ordinary farm practices and farming machinery and in being preventive, indirect or not measureable, so one does not know how effective they really are. They are used in advance of insect damage, so they are more preventive than cure. They are economical and especially effective against pests of low value crops. Results from cultural practices effects the weak point in the pest insect's life cycle or adaption to the environment (Pfadt 1971; Ross 1967). Hence, it is critical that one understand the life history and habits of specific insect pests (Sorensen and Baker 1994).

Since these control tactics usually modify the relationships between a pest population and its natural environment, they are also known, less commonly, as ecological control methods. Simplicity and low cost are the primary advantages of cultural control tactics, and disadvantages are few as long as these tactics are compatible with a farmer's other management objectives (high yields, mechanization, etc.). They are economical and especially effective against pests of low value crops.

Cultural control includes sanitation, destruction of crop residues and weeds, burying infested fruit in holes, covering or using screens over the top vegetative portions to prevent insects from escaping, burning crop residues after harvest, and keeping fields and areas surrounding field clean by hand removal or use of chemicals to destroy weed or alternate wild hosts where insects may survive until the next planting of crops (Metcalf et al. 1962; Pfadt 1971; Ross 1967). The following practices are employed in vegetable pest management.

Preparatory Cultivation

Prevention is better than the curative methods thus the preparatory cultivation methods including clean cultivation, systematic pruning of infested plant parts play a vital role in the control of insect pest populations. Clean cultivation is recommended for *Hellula undalis* because it feeds and develops on certain weeds such as *Cleome rutidosperma* and *C. viscosa*, which act as alternate hosts during the off seasons. Proper cutting and removal of infested plant parts of eggplant help to reduce the incidence of *Leucinodes orbanalis* and some sucking pests (mealy bugs) (Alam et al. 2003).

Tilling or Cultivating Soil

Tilling or cultivating the soil by altering the texture of soil and the chemical composition, the percentage of soil moisture, temperature and soil organisms can adversely affect the growth and development and survival of insect pests. This is the case with soil borne insect larvae or where pupation occurs in the soil (Metcalf et al. 1962; Pfadt 1971; Ross 1967; Westcott 1964; Yepsen 1977). Racking up and hoeing of the soil around melon plants and other vegetables is effective.

Flooding

Flooding is a method to drive out the hibernating larvae and other stages of insect pests. It is a standard agronomic practice to control soil borne insect pests. Soil pupating, leaf consuming lepidopteran larvae (*S. litura* and *S. exigua*), can be controlled by flooding the field.

Overhead Irrigation

Overhead irrigation of water cress at night reduced the number of eggs laid by the diamond-back moth. This has been observed in collard production as well (Tabashnik and Mau 1986). Overhead watering also decreases codling moth, flight, oviposition and egg and larval survival (Prokopy and Croft 1994).

Crop Rotation

Changing or rotating crops in different families can help to control insect pests (Metcalf et al. 1962; Pfadt 1971; Ross 1967; Sorensen 1977; Westcott 1964; Yepsen 1977). Insects reduced by rotations have a long life cycle, a limited host range and are immobile in one stage of development. Changing crops isolates pests from their food supply. Planting the same crop or crops in the same family or relay planting the same crops before the previous crop is harvested increases insect pest populations and their damage. Rotations are more effective in agronomic crops than in horticultural crops like fruit and vegetables. Also be aware of alternate wild host plants or volunteer plants from the previous crops that exist near, as they serve as reservoir hosts to infest your later plantings.

Rotation of crops from year to year will help to destroy insect pests specific to some crops over others (Weber et al. 1994). Among the insects that injure tropical vegetables the number of general feeders is very small. So be knowledgeable about the host plants of your problematic insect pests and alternate from host to non-host as best you can manage.

Crop rotation with non-host crops is an effective method for managing insect pests attacking tomato. The selection of an appropriate non-host crop is challenging, because most of the tomato pests are highly polyphagous and feed on several agricultural and horticultural crops as well as weed plants. Non-solanaceous crop rotation is an effective way to reduce the population buildup of brinjal shoot and fruit borer. However, careful consideration in choosing the crops for rotation is imperative, because the crops selected (e.g., cotton or okra) may also support other common pests e.g., whitefly, leafhopper and aphids. Cotton followed by okra will increase leaf hopper populations and they may harbor the little leaf of eggplant disease. Hence, the identification of suitable and non-host crops is vital role when employing cultural control tactics.

Time of Planting

Variations in time of planting are also important and can result in plants out growing those late arriving pests. Time of year and weather conditions, hot and dry or wet can affect the crops and their insect pests. Inter planting different plant species in some fields can slow down the pest species from locating the crop and establishment. This is especially true for single host pests or those with just a few hosts. Relay plantings should also be avoided in space and time in that such a practice has the advantage of easy movement and quick establishment of all pests.

Trap Cropping

Growing of preferred or susceptible plants of important pest species (trap crop) near a major vegetable crop and subsequently destroying it or killing it with insecticides is an effective control tactic. Further, if the trap crop is flowering the nectar may serve as a food for natural enemies (predators or parasitoids) and therefore enhance the natural control of insect pests.

Growing castor as a trap crop, on the borders of vegetable fields (onion, chillies, etc.) reduces *S. litura* infestations. The castor should be sown 1 month prior to transplanting. Inter cropping of a one row of a tall variety of marigold after every 16 rows of tomato acts as a trap crop. It helps to reduce the incidence of tomato fruit borer and root knot infestation. The 40 days and 25 days old marigold and tomato planting of seedlings respectively is ideal for the control of insect pests in tomato (Fig. 5.3).

Two rows of mustard between every 25 rows of brassica, is an effective way for reducing the diamond-back moth populations and their damage. One row of mus-

Fig. 5.3 Intercropping tomato with marigold

tard should be sown 15 days before the brassica planting, and a second sowing is recommended on the adjacent ridge on the 25th day after planting brassica (Srinivasan and Krishnamoorthy 1992).

Transfer of Pest Management Technology to Vegetable Farmers

Dissemination of pest information and pest control strategies to end users, in a timely manner, is the responsibility of university researchers and extension service, pest control industry, government extension agencies, local pesticide dealers, trained local farm advisors, field consultants and NGO professionals (Rabb and Guthrie 1970; Ross 1967; (Fig. 5.4). In the United States the Land Grant Universities in each state conduct research and translate the findings into specific control recomendations for the farmer, home owner, governmental and private agencies, field consultants and farm advisors. Traditionally, local country extension agents address the local geographical information for practical adoption of pest control methods and effective use. Much effort and support has been directed to "train the trainer" programs by donors (foundations, organizations, and NGOs) Ministries of Agriculture. This technical information is based on detailed knowledge of local professionals on the insect pests, their life history, and the latest control methods developed. They may identify the pest, do some insect monitoring and even some surveying and forecasting of pest populations. They conduct pest control demonstrations on farms and follow up with field days and even provide specific recommendations of specific control methods to choose and to use. Hard copy publications and more recently online or electronic information are used to place requested and useful information in the hands of the farmers or advisors. This approach is a life-long professional endeavor to extend the latest findings and to help in the safe and economical production of a constant and sustainable food supply for all consumers.

Fig. 5.4 (**a**), (**b**), (**c**), Technology transfer to vegetable farmers

Fig. 5.4 (continued)

Conclusion

Selection and use of methods of insect pest control, or management, is based on the following considerations. The use of one control method over another depends on many factors. Among these are the following: economics, cost comparisons between all control methods, technical difficulties, availability, dependence on chemicals, lack of efficacy, need for more research, impractical for one or more reasons, and lack of specific targeting and timing. Other considerations include these statements: Is the need in pre-harvest, time of harvest or postharvest situations? Is the crop of high or low value? Is the use in developed or developing countries where labor is available and shipping to distant or close markets is possible? Is the market fresh or processed, near or distant? Obviously economics in costs verses benefits, cost relative to technologies that exist, the dependence on chemical insecticides, and the availability of technologies must be considered (Novartis 1997; Oseto 2000; Panneton et al. 2001a, b; Vincent et al. 2001, 2003). Targeting is a major challenge in developing physical and cultural control methods for field use (Sorensen 1972–82, 1978–80a, b, 1987, 1996, 2002, 2005b). Likewise, is the difficulty with insecticide sprays, where less than 0.03 % of the foliar spray against aphids on field beans is effectively used for killing the insect pests (Matthews 1992).

As we move to developed countries legal, environmental and safety regulations may restrict the use of certain practices and particularly pesticides. Competition for markets within and between countries affects the methods used or required. In post-harvest vegetables there is zero tolerance for pest damage and pest presence. Hence, physical, mechanical and cultural, control is often applied early as a preventative and throughout the growing period along with timely applications directed at targeted pests with selective and effective safe insecticides.

Advances in computer technologies (expert and GPS Systems), the increased use of weather balloons and drones, weather and pest forecasting, the availability of digital and internet sources have provided a great deal of technical and timely information on insect pests, their biology, control and management at everyone's fingertips. Insect modeling and application in the field along with computer capabilities and high-speed sensor technologies have helped to target pests with the effective use and selection of any and all methods of pest control (Panneton et al. 2001a, b; Terry et al. 1983; Vincent and Chagnon 2000; Vincent et al. 2003).

A constant concern is the widening technological and economic gaps between developed and developing countries (Oseto 2000; Panneton et al. 2001a, b) With different agronomical, horticultural and entomological problems under temperate and tropical conditions, there still exists a need to adopt effective IPM programs including physical and cultural practices and even genetically engineered plants (GMO) in pest control strategies (Novartis 1997; Rabb and Guthrie 1970). Food production and human health standards can help to meet the growing demands of global markets through exchanging technology with those in temperate and tropical countries, in both developed and developing countries, as the world grows smaller and communication and resources are shared. Technical solutions to manage insects can be applied in all socioeconomic, ecological and political realities over the period of time (Novartis 1997; Rabb and Guthrie 1970; Ross 1967; Sorensen 2008, 2009; Vincent et al. 2003).

Acknowledgement We thank Charles Vincent, Guy Hallman, Bernard Panneton and Francis Fleurat-Lessard for their excellent Annual Review in Entomology 2003: 48:261–81 article "Management of Agricultural Insects with Physical Control Methods" that contained an effective template that was modified, and for the published literature that was reviewed in preparing this chapter and should be useful to those interested in nonchemical control methods. The *Annual Review of Entomology* is online at http://ento.annualreviews.org. We trust that all appreciate these overviews and find the content of great practical use in feeding a hungry world.

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