



## Biological pest management by predators and parasitoids in the greenhouse vegetables in China



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### HIGHLIGHTS

- China has the largest area in the world under greenhouse vegetable.
- Whiteflies, aphids, spider mites and thrips cause 18% production loss.
- 14 Natural enemies used against 8 pests in 8 crops between 1988 and 2007.
- More than 40 species of predators and parasitoids have been applied in greenhouse.
- The importance of using native species rather than non-native agents is increasing.

### GRAPHICAL ABSTRACT



### ARTICLE INFO

#### Article history:

Available online 5 July 2013

#### Keywords:

Biological control agent  
Greenhouse structure  
Integrated pest management  
Mass production  
Protected agriculture

### ABSTRACT

China has the highest greenhouse-based production in the world. In 2010, the area of greenhouses devoted to vegetable production was estimated at 4.7 million ha. With the increasing costs of pest control, expanding pesticide resistance and the growing consumer concern regarding pesticide residues in fresh vegetables, a strong demand for applying non-chemical control methods is emerging in China. Biological control in the greenhouse environment is a viable alternative to pesticide use from both environmental and economic perspectives. Although we have only 17 cases of fully documented, successful biological control operations from China, involving 8 crops, 8 pest species and 14 species of natural enemies, the use of the biological control agents is much more widespread. There are 7 commercial companies and facilities producing 21 species of natural enemies, and most of them are available country-wide. Several of these employ a rearing system using artificial diets, and many now move to an integrated

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production system, including the mass production of the biocontrol agents, quality control, methods of long-distance transportation, release recommendations, and user feedback. While initially these systems relied on introduced natural enemies, they increasingly develop modified systems using native natural enemies. The increasing demand for pesticide-free, high quality vegetable produce year-round and the existing certification schemes make it very likely that the use of biocontrol agents will continue to increase in China.

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## 1. Introduction

Greenhouses protect crops against adverse environments, providing plants with improved environmental conditions. In greenhouses, crops can be produced year-round, with yields and qualities often higher than those produced in the open field. In recent years, great progress has been made by the greenhouse vegetable industry in China. Now, China has the highest greenhouse-based vegetable production in the world, on an estimated 4.7 million ha, nearly twice the area in 2004 (Yu, 2011). The output value of greenhouse vegetables was US\$110 billion in 2010, which accounted for more than 65% and 20% of output value of vegetables and crops, respectively (Zhang et al., 2010a,b). The per capita production of greenhouse vegetables was more than 200 kg, and about 40 million people employed by the industry.

Most of the greenhouse vegetable production is labour- and energy-intensive, thus requires a high level of technology to obtain adequate economic returns. Quality is a high priority for greenhouse vegetables, requiring great care in pest and disease management, not only to secure yields but also to obtain a high cosmetic standard (Gullino et al., 2002). With the increasing costs of chemical control, expanding pesticide resistance and the growing awareness of the risks of pesticide residues in fresh vegetables from consumers, strong demand for non-chemical control methods is emerging in China. Biological control in the greenhouse environment has been shown to be a viable alternative to pesticide use from both an environmental and economic perspective.

The aim of this review is to summarize the progress made by the greenhouse vegetable industry in China, the occurrence of pests, and the suitability of greenhouses for biological control. We summarize the production of natural enemies and their utilization in greenhouse IPM regimes. Finally, we discuss the future opportunities and challenges in biological control in the greenhouse vegetable industry in China.

## 2. The greenhouse environment and the occurrence of pests

Over the last thirty years, several types of greenhouse facilities, production modes and technology systems were established in different geographical regions in China. The structures adopted for vegetable production include 4 main types: low tunnels (plastic row cover), high tunnels (walk-in tunnels), sunlit greenhouse (Chinese solar greenhouse) and multi-span greenhouse (plastic and glass covered) (Fig. 1).

### 2.1. Low tunnels

They account for 40% of the total greenhouse area. These are small structures that provide temporary protection to vegetables, and are mostly used in small, family farms. Their height is generally 1.0 m or less, with a width of 2.0–3.0 m. Since there is no aisle for walking, cultivation must be performed from the outside. The framework of such “greenhouses” is mostly built of bamboo, and covered with plastic film.

### 2.2. High tunnels

This structure accounts for about 40% of the total greenhouse area. Their height is generally 2.4–3.2 m, and width is 8.0–12.0 m. The framework is built of bamboo canes, wood or steel, and covered with plastic film. About half of the area covered by such structures is distributed in the middle and lower reaches of Yangtse River, located in Central and Eastern China. They are used for year-round production of vegetables. Most of these structures are used on small farms.

### 2.3. Sunlit greenhouse

These are typical structures developed to fit the special climate in China, and they account for about 20% of the total greenhouse area. They are also called Chinese solar greenhouse. Sunlit greenhouses are mainly used in northern China, where sufficient solar energy is available. This type of greenhouse typically has a single slope normally covered by plastic on the southern side, and the other three sides are solid walls. They generally have a height of 2.8–3.5 m, width of 6.0–9.0 m, and their length is 40–120 m; the north wall thickness is usually 0.6–1.5 m. These greenhouses are warmed up by solar energy during the day; during the night, the temperature is maintained by covering the southern side by an insulating cover, made of waterproof puffed polyethylene (PE), cotton felt, or straw, and related materials. In these structures, year-round production of vegetables could be achieved even in cold regions without additional heating. This type of greenhouse is used both by small farms and large agricultural corporations.

### 2.4. Multi-span greenhouse

This structure accounts for no more than 0.5% of the total greenhouse area. Multi-span greenhouses have a protective surface area smaller than a number of single span greenhouses of equivalent production capacity (soil area). This results in less heat loss and substantial energy savings, contributing to a better cost of production per unit ratio. Moreover, multi-spans are typically more robust in design, and thus suffer less damage during storms or high wind. This type of greenhouse is covered by glass or plastic foil. When covered by glass, they can provide optimal conditions for use of natural enemies. There is about 1300 ha of glass greenhouse area in China, making up only 0.1% of the total greenhouse area (Zheng et al., 2005). The temperature can be maintained at 15–35 °C and the humidity can be reduced or raised to an optimal level through the use of heaters, fans and other devices.

Greenhouse internal climatic regimes, influenced by the type of greenhouse structures and location, have important consequences on the occurrence of pests and their natural enemies. Greenhouses have high plant densities with non-stop production systems which lend themselves to the spread of pests; additionally, well fertilized and irrigated crops are often more sensitive to outbreaks of pests than outdoor crops (Gullino et al., 2002). According to a report from the Ministry of Agriculture of China, the annual losses of vegetable production caused by pests reach 18%. The main pests in greenhouses are sucking pests like whiteflies, aphids, thrips and

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