Literature survey about biological control of insect pests and diseases of chili in Thailand

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1. Background

Chili (Capsicum) is one of the most important horticultural crops in Thailand, and is presently experiencing severe damage caused by pests and diseases despite the use of large amounts of pesticides. Therefore, it is important to develop a new technique for pest and disease control as a component of an environmentally sustainable Integrated Pest Management (IPM) system for chili.

Based on these backgrounds, JIRCAS and Department of Agriculture, Thailand (DOA) has been implementing a collaborative research “Development of an environmentally sustainable technique for controlling pests that transmit virus diseases” during April 2014 - March 2016. This research aims to select a candidate of companion plant for attracting and harboring indigenous natural enemies in chili pepper field, in order to develop a control technique for pests especially those that can transmit virus disease.

This report introduces the highlights of previous studies about biological control of insect pests and diseases of chili in Thailand in order to understand the current situation of the study subject.

2. Highlights of previous studies

Among the pests of vegetables, thrips is considered to be the most destructive sucking insect in both the highland and lowland areas. The crops most seriously attacked by thrips are chili and others (Bansiddhi and Poonchaisri, 1991). The adults and larvae of chili thrips (Scirtothrips dorsalis Hood) feed on sap of young leaves and fruits. The affected parts of chili plants become stunt and various symptoms are observed like leaf curl with silvery markings, rough skin and cracks in young fruits. For chili diseases, bacterial wilt caused by Ralstonia solanacearum is an important disease and spreading throughout the country (Titatarn, 1985). Nematodes (Meloidogyne incognita) also cause root gall disease. All three factors cause chili yield losses.

Biological control using natural enemies associate with banker plants and chili varieties resistant to pathogenic bacteria have been used to reduce above problems in chili cultivation (Osborne and Barrett, 2005, and Nguyen and Ranamukhaarachchi, 2010).

The literature survey found several studies about biological control of insect pests and diseases of chili in Thailand though the number of studies was limited.

Petcharat et al. (2007) and Petcharat (2010) compared the effects of biological pest control with conventional control in the field experiments. The first study found that though the cost of biological control was higher, the chili yield was higher than that of conventional control. The second study identified various insects and mite pests of chili in several chili planting areas in Thailand but found only one natural enemy. Samoh (2013) focused green lacewing, Mallada basalis (Walker), a natural enemy of chili pest, and found that though the cost of biological control with green lacewing was higher than that of conventional control, farmers could expect additional income from pigeon peas, which were intercropped with chili as lacewing’s food plants. Klangsinsirikul and Chupraphawan (2011) also investigated the effects of natural enemies, Mallada basalis, Trichoderma harzianum and Bacillus thuringiensis var. aizawai to control pests of chili in field experiments.

The other studies focused various alternative pest control technologies. Uraisakul (2003) investigated the effects of plant extracts including Neem, Hyptis, Cymbopogon, Chromolaena, Eucalyptus, Melaleuca, Stemona, Veronia, Andrographis, Derris, Nicotiana and Annona. Thaveechai et al. et al. (1999) and Watcharachaiyakup et al. (2005) studied about disease resistant chili varieties, while Tangechitsomkid et al. (2009) and Chunram et al. (1991) investigated the effects of crop rotations.

The summaries of respective studies are shown as below.

Jiraporn PETCHARAT, Siwaporn HOKUL and Varaporn CHAIYAMA (2007) Biological control of insect and mite pests of chili.
Comparative study between biological control (biocontrol) and farmers’ conventional pest control practice with insecticide (chemical control) was done in chili growing area. In biocontrol field, lacewing *Mallada basalis* (Neuroptera: Chrysopidae) were released to control small size pests (e.g. thrips, aphid, mite) and eggs of other pests of chili. Average weight of chili from biocontrol field was 317.20 g/plant or 507.52 kg/Rai (1 Rai = approx. 0.16 ha) while that from chemical control field was 227.89 g/plant or 364.62 kg/Rai. Total cost of control in biocontrol field using lacewing was 9.72 Baht/m² or 15,552.00 Baht/Rai while in chemical control field was 2.66 Baht/ m² or 4,256.00 Baht/Rai. The cost of pest control per chili products in biocontrol practice was 70 Baht/kg and that of the chemical control was 35 Baht/kg. The higher cost of biocontrol is mainly coming from the breeding cost of *M. basalis*. Biocontrol chili using lacewing gave 35,526.40 Baht/Rai as output while chemical control gave 22,764.70 Baht/Rai. In 1 Rai biocontrol chili gave 8,668.56 Baht more than chemical control chili.


Various insect and mite pests of chili found in chili planting areas in Rattaphum and Ranote districts, Songkhla province; Khao Chaison and Lumpum districts, Phattalung provinces; and Chianyai and Phakpanang districts, Nakorn Sri Thammarat province during the survey in October 2006 - September 2007. However, only one natural enemy, braconid parasitoid of fruit fly, *Diachasmimorpha longicaudata* Ashmead was found in the same areas.

The cost of pest control, income, number of fruit fly *Bactrocera* spp. and fruit fly parasitoid *Diachasmimorpha longicaudata* (Ashmead) collected from chili plots were surveyed in the chili fields with chemical insecticide control and those with biological control using *Mallada basalis* (Walker). The results showed that 1) the average weight of chili in biological control plot (BP) was higher than chemical insecticide control plot (CP), 2) the average number of fruit fly in BP was higher than CP, 3) the average cost of chemical control was cheaper than biological control and 4) the average income of chemical control was higher than biological control.


To conserve the green lacewing *Mallada basalis* (Walker), an effective insect predator, released in chili plots for insect pest control, 3 main areas of study have been done: 1) selection of adult *M. basalis’* food plant as an intercrop in chili plots, 2) toxic effects of insecticide and acaricide use in chili pest control on *M. basalis*, and 3) use of *M. basalis* to control insect pests in the conservation plot where chili was intercropped with the lacewing’s food plant and the less toxic insecticides and acaricides were appropriately applied.

To select *M. basalis* adult’s food plant, flowers of the pinto peanut *Arachis pintoi* cv. Amarillo, cosmos *Cosmos bipinnatus* and pigeon pea *Cajanus cajan*, together with water, honey, and yeast were offered to the adult lacewing in laboratory. It was shown that pigeon pea flowers +honey +yeast +water provided the highest longevity (male = 44.00±8.80 and female = 50.41±11.35 days) and the highest number of eggs laid per female (501.80±76.99 eggs/female). The pigeon pea *C. cajan* was then selected as an intercrop plant in the lacewing conservation chili plot. Studies on the toxicity of insecticides (fipronil, imidacloprid and carbosulfan) and acaricides (abamectin and sulfur) recommended for chili insect and mite pests on the egg, larva, and adult *M. basalis* were done using topical and residual contact methods. Direct contact of each insecticide and acaricide through typical applications revealed 100% mortality of the 1st, 2nd instar larvae and the adult *M. basalis*, direct contact also caused higher toxic than residual contact. The egg and the pupal stages of *M. basalis* were tolerated more than the larva and the adult stages. Toxicity of the tested insecticides and acaricides on *M. basalis* was grouped into 3 categories. Carbosulfan had the highest toxicity, while fipronil, imidacloprid and abamectin were moderately toxic and sulfur was the least toxic.

To control insect pests in a conservation chili plot, the infestation of insect and mite pests, the number of the insects natural enemies, and numbers of *M. basalis* were compared with those of the control (no control action), chemical control (insecticides and acaricide applied), biological control (released *M.
basalis), and conservation biological control (release of M. basalis, and chili was intercropped with pigeon peas C. cajan) plots. Heavy infestations of the chili insect pests, cotton aphid Aphis gossypii and chili thrips Scirtothrips dorsalis, were found in all the test plots from seedling through to flowering stage of chili. Four species of natural enemies (anthicid beetle Anthicus sp., green lacewing M. basalis, lady beetle Menochilus sexmaculatus (Fabricius) and lynx spider Oxyopes sp.) were found in biological control and conservation biological control plots while there were 3 species in the control plots and only 2 species in the chemical control plot. Chili production in the conservation biological control plot was the highest among the tested plots.

The pest control cost in biological control and conservation biological control was higher than the chemical control plots due to the M. basalis cost. The chili production and gross revenue per plant was higher in the chemical control plot than other plots, but in the conservation biological control plot pigeon peas C. cajan which were intercropped with chili helped conserve the green lacewing M. basalis and gave more income from the pea products.

Sukanya KLANGSINSIRIKUL and Yuwadee CHUPRAPHAWAN (2011) Utilization of natural enemies for control of chili pests.

Utilization of natural enemies, Mallada basalis, Trichoderma harzianum and Bacillus thuringiensis var. aizawai to control pests of chili “Hau Rua” in fields were conducted in three cropping seasons during November 2007 to May 2010. The experiment was Randomized Complete Block Design (RCBD) with three treatments, i.e. natural enemy control treatment, chemical control treatment and non control treatment. The natural enemy control treatment (released 5,000 larva/Rai and sprayed B. thuringiensis) showed the least number of M. persicae among the three treatments and population of thrips was same as the chemical control. For Virus diseases, Anthracnose and Frog eye leaf spot were found in all three treatments and higher level of infection was observed in non control treatment. The natural enemy control treatment and chemical control treatment showed the possible symptoms of Bacterial leaf spot. The highest height of crops and diameter of canopy were observed in the natural enemy control treatment. The lowest number of fruit rot (3.08%) was observed in chemical control treatment. Total cost of control in natural enemy control treatment was 4.54 Baht/plant while 1.97 Baht/plant in chemical control treatment.


The effect of various plant extract application on the growth of chili plant, was examined at Herbs Laboratory, Huntra Campus, Rajamangala Institute of Technology, Ayuthaya province. The treatments include Neem extract, Hyptis extract, Cymbopogon extract, Chromolaena extract, Eucalyptus extract, Melaleuca extract, Stemona extract, Veronica extract, Andrographis extract, Derris extract, Nicotiana extract, Annona extract, mixture of some of these plant extracts, suspension of chemical treatment (Keltane), control (water spraying), and suspension of Andrographis extract. Chili trees treated by the suspension of Annona extract showed significantly higher fruit production than the other treatments.

The effect of Annona suspension at 100 ppm on controlling broad mite was investigated. Annona suspension killed 100% of eggs and larvae of broad mite, 80% of adult in the laboratory room. The population of broad mite in chili trees was decreased by Annona suspension. The suspension also killed 9% of Eryophyid mites, 50% of Scirtothrips dorsalis, 80% of Aphis gossypii but it did not harm Amblyseius longicaudatus (predaceous mite) at eggs and adult stages.


Ralstonia solanacearum (RS) causes bacterial wilt of pepper. To screen resistant varieties to RS, 8 week old pepper seedlings were infested by soil drench through root wounds and severity of infection was
observed. Among the 10 pepper varieties, CA363 were moderately resistant and CA319, CA362, CA392, CA500, CA514 and CA651 were susceptible.

Population and distribution of RS in inoculated pepper plants was also investigated. C00835 showed high disease score, 5 and population of RS in the plant was also high. Resistant line, PBC006 showed no wilt symptom but RS population was lesser than susceptible line. It indicated that the resistant line was infected by bacterial pathogen but showed no wilting symptom.


Bacterial wilt, caused by Ralstonia solanacearum, is a major problem among important economic crops. Once infected, extracellular polysaccharide (EPS) produced by these bacteria contributes in wilting mechanism by blocking water translocation in xylems. The aim of this experiment is to study the mechanism of resistance in pepper related to EPS production. Comparison of resistant levels among eight pepper (Capsicum annum) cultivars, infected with R. solanacearum, was performed. Bacterial sizes found in infected plant exudates of resistant cultivars, PBC495 and CA364 (0.475x0.895 and 0.560x1.049 μm) were smaller than that in CA363 (0.632x1.146 μm), the moderate susceptible cultivars. Amount of hexosamine in PBC495 was 2.2 mg/gfw (gram fresh weight) while that of CA363 was 8.45 mg/gfw. R. solanacearum (~1000 cfu) was cultivated with stem fluid extracted from the uninoculated and inoculated chili (resistance and susceptible cultivars). After the cultivation, stem fluid from resistant pepper cultivars had 0.002-0.34x10^5 cfu/ml of R. solanacearum while that from susceptible cultivars had 0.08-2x10^5 cfu/ml. This indicated that the inhibitory mechanism in bacterial wilt disease of tolerant pepper cultivars might be due to inhibition of EPS production and production of some antimicrobial substances.


Technology for controlling chili root gall disease caused by Meloidogyne incognita was experimentally tested in both greenhouse and epidemic areas of root gall disease with farmer participation. Evaluation of chili varieties resistant to root gall disease was also conducted in Northeast of Thailand during October 2007- March 2010 in order to increase chili yield and farmer income. At first, nematode was purged from the seedling plot by burning rice husks for the duration of 6-8 hours prior sowing chili seeds. Decreasing the nematode population in filed was achieved by pre-planting sun hemp (Crotalaria sp.) at the ratio of 5 kilogram/Rai followed by incorporating the plant on pre-flowering stage into the soil prior to replanting chili seedlings. It was found that, in the pre-planted fields with sun hemp, the root gall disease was decreased by 50-75% whereas the chili yields was increased by 21.35 %, resulting in increasing incomes and profit by 31.41 % compared to the fields without pre-planting sun hemp. The farmers have adopted the new technique for controlling nematodes in 400 Rai areas. The technology transfer has been in progress in Northeast provinces of Thailand and it successfully controlled root gall disease. The 860 accession numbers of chili were screened and evaluated for their resistance to Meloidogyne incognita. Only 5 accessions were confirmed to be highly resistant; CA1352, CA747, CA158, CA1420 and CA1429. 13 accessions were either highly resistant (HR) or very resistant (VR).


Crops were grown at Sisaket Horticulture Research Centre during October 1987 to September 1989 in experimental plots where the root - knot nematode, Meloidogyne incognita (Kofoid & White) Chitwood (M. incognita), had previously increased. The population of M. incognita per 500 g of soil was 2,000 in the second stage larvae (L2). Cropping patterns were Chili-Chili (C-C), Chili-Peanut (C-P), Chili-Baby corn (C-B), Chili-Shallot (C-S), Chili-Garlic (C-G) and Chili-Asparagus (C-A). Growing chili as the first crop increased the nematode population to 3,870 L2 per 500 g of soil from 2,000 L2 for the initial population. After harvesting chili, the second crops were grown. A crop sequence of C-C increased L2 of M. incognita
to 4,020 and lowered the yields to 46.34 % of the first crop. Shallot and garlic after chili (C-S, C-G) decreased L2 of the nematode. Chili followed by peanut (C-P) gave complete control of *M. incognita* and L2 was not found at all. The patterns of C-B also decreased *M. incognita* to 1,218 and C-A to 84 L2, but yields did not differ statistically between treated and non-treated plots. However, C-P increased the population of other nematode species, *Criconemella ornata* while C-A increased *Rotylenchulus reniformis*.

3. References


