Thrips in Southeast Asia

Proceedings of a regional consultation workshop, Bangkok, Thailand, 13 March 1991

Asian Vegetable Research and Development Center

Thrips in Southeast Asia

Proceedings of a regional consultation workshop,
Bangkok, Thailand, 13 March 1991

N.S. Talekar, Editor

Asian Vegetable Research and Development Center

Talekar, N.S. (ed.) 1991. Thrips in Southeast Asia: proceedings of a regional consultation workshop, Bangkok, Thailand, 13 March 1991. Asian Vegetable Research and Development Center, AVRDC Publication No. 91-342, 74 p.

ISBN: 92-9058-046-1

Technical editing: Reginald MacIntyre
Cover photo: *Thrips hawaiiensis* (Morgan) by N.T. Chang

(The use of trade names does not constitute endorsement of nor discrimination against any product by the Center)

2

CONTENTS

Foreword

In recent years thrips have been causing increasing damage to food crops worldwide. They are especially serious in the tropics and subtropics. Most thrips species are polyphagous and feed on foliage, flowers and fruits from seedling stage up to harvest. Thrips infestations can result in total crop failure. Some thrips transmit virus diseases.

Because of their ubiquitous nature and concealed feeding habit, the characteristic damage they cause, such as leaf crinkling or flower drop, can be mistaken for virus diseases or physiological disorders. The concealed feeding habit, often in flowers and vegetative buds, makes thrips difficult to control by conventional means, and far less accessible to attack by natural enemies.

Farmers use costly toxic chemical insecticides, which provide only partial control of the pests. Thrips seem to develop resistance to the insecticides, which often kill its natural enemies resulting in explosive increases in thrips populations. Alternate measures to combat the thrips are essential if we are to avoid repeating costly mistakes made in our over-reliance on chemical insecticides in the control of diamondback moth, armyworms, tomato fruitworm, and others. Chemical insecticides are used intensively on all crops in Southeast Asia. The constant use of toxic chemicals is bound to exacerbate the thrips problem in years to come.

This workshop was organized by AVRDC to discuss the thrips problem in Southeast Asia, mainly the Philippines, Indonesia, Malaysia and Thailand. Thrips specialists from the national programs were invited to discuss the potential for collaborative research to better utilize available expertise and resources. This is especially important for AVRDC since we have initiated research on pepper, and will soon initiate research on onion and possibly eggplant. All three crops are highly vulnerable to thrips damage.

The country reports and presentations from two resource persons from Japan and Taiwan, plus the paper on AVRDC's strategy to strengthen national programs in the region to carry out effective research on thrips, provide useful information to researchers and policymakers.

E.Q. Javier
Director General
AVRDC

Thrips on Vegetable Crops in the Philippines

E.N. Bernardo
Department of Entomology
College of Agriculture
University of the Philippines at Los Baños
College, Laguna, Philippines

Abstract

Thrips infestations have been observed on several vegetable crops, but serious damage (severe leaf bronzing, then drying) has been reported only on tomato, pepper, eggplant, watermelon, muskmelon, cucumber, garlic and potato in low-elevation areas. The species attacking garlic has not been identified but those on the other crops are predominantly *Thrips palmi* Karny and *Megalurothrips usitatus* Bagnall. The former is the only well-studied species locally. Its developmental period is 11-16 days. It has been collected from 16 species of crops and weeds, and has been observed infesting buds, flowers, leaves and occasionally young fruits. Its natural enemies include anthocorid *Orius tantillus* Motschulsky, lygaeid *Geocoris* sp., mirid *Campylomma livida* Reuter and *Tapinoma*, two chalcids, five species of *Amblyseius* mites, and six spider species. Farmers depend on pesticides for thrips control, using two to four chemicals in succession, applied at 3-14-day intervals depending on infestation level. The commonly used pesticides are profenofos + cypermethrin, methamidophos, endosulfan, methiocarb, azinphos-ethyl, profenofos, deltamethrin, cypermethrin, monocrotophos, dimethrin and formetanate. Some farmers still experience large yield loss or total crop failure despite the frequent pesticide applications. Potato germplasm with some resistance to thrips has been identified for possible use in crop improvement.

Introduction

Vegetables are regular components of the Filipino diet. They are therefore among the most widely grown crops in the country, based on the number of families producing them. They are grown in small gardens in rural backyards primarily for daily family consumption, in larger plots for sale in nearby markets upon harvest, and in much larger areas for transport to distant urban centers where the crops are not produced but are in high demand. The subsistence farmers usually raise one or two kinds of vegetables that are relatively easy to grow, more tolerant to adverse conditions, productive for long periods although in smaller quantity, and certain to produce some yield even if grown with minimum care and little or no inputs other than water.

The backyard growers generally prefer native or traditional varieties familiar to family members. However, the more progressive farmers who grow crops for sale select vegetable varieties that are high-yielding and in great demand by consumers. They provide the attention and inputs that give maximum yield. The severity of infestation by insect pests in many instances is directly related to the scale of production, based on the incidence and severity of damage reported by farmers producing different vegetable crops.

Thrips are among the insect pests reported in more recent years as highly destructive to a number of vegetable crops in medium and large-scale production. However, the backyard farmers have not been complaining about them, either because thrips occur in negligible numbers or the subsistence farmers are not observing their crops sufficiently closely to notice the presence and abundance of insect pests.

This review is a synthesis of data reported in student theses, published reports on completed or ongoing studies, personal accounts of some field technicians and extension workers, and personal observations.

Species of Thrips Infesting Vegetable Crops

The most predominant and widely occurring species is *Thrips palmi* Karny. It was presumed to be *Thrips tabaci* Lindeman until the late 1970s. The species has been reported to cause severe damage on watermelon, muskmelon, cucumber, tomato, eggplant and potato grown in low-elevation areas. Several cases have been reported where thrips damage resulted in total crop failure. Severe thrips damage on garlic has been reported also, but the species involved was not identified. In some places, high populations of *Megalurothrips usitatus* Bagnall also occur on tomato and potato. The two species sometimes occur together, but they can be differentiated readily by their color. *Thrips palmi* is light orange-brown, and *M. usitatus* has a black body.

Other vegetable crops attacked by thrips, but not so severely, are string bean, mungbean, winged bean, snap bean, pole bean, cowpea, bitter gourd, bottle gourd, luffa, squash, onion, cabbage, radish, okra, and baby corn. The two thrips species have been collected only on some of these crops, suggesting the possibility that there are other species involved.

The plant parts attacked are buds, flowers, leaves, young fruits occasionally, and silk in the case of baby corn. On the leaves, where the damage is usually more noticeable, the symptom is bronzing or silvery patches, becoming more extensive and turning brown, then the entire leaf dries up and dies.

Farmers have reported thrips population buildup. Some said that initially the more serious pests they encounter in their fields are fruitworm (*Helicoverpa armigera* Hübner) on tomato, shoot and fruit borer (*Leucinodes orbonalis* Guenee) on eggplant, squash beetle (*Aulacophora similis* Olivier) and leaf folder (*Diaphania indica* Walker) on melons and cucumber. After applying insecticides several times to control these pests, the thrips population increases significantly, and becomes the more damaging species and the one hardest to control. Other farmers claim that thrips become serious as the plants grow older even with no pesticide application earlier.

In some experiments in production farms of the Institute of Plant Breeding (IPB), Los Baños, *T. palmi* has caused considerable damage during the past few years, especially on eggplant. Some plantings intended for seed production were abandoned due to severe thrips damage. Application of pesticides as often as every 4 days failed to provide satisfactory control. In contrast, the entomologists in IPB led by the author, who were screening eggplant and tomato germplasm materials for resistance to the pest, had difficulty establishing and maintaining the required high thrips population in their fields unsprayed with pesticides. Heavily infested eggplant leaves were collected from the plant breeders' field and introduced to the entomologists' evaluation field, but the resulting high thrips population could not be maintained. The entomologists then decided to copy the plant breeders' crop protection practices. After four sprayings, the thrips population increased to such a high level that the materials which were observed earlier as "more tolerant" were severely damaged. This suggests the possibility that some natural enemies suppressing thrips population buildup were eliminated or drastically reduced by pesticide application.

Studies on Thrips Affecting Vegetable Crops

Biology, host range and natural enemies. Palacio (1978) studied the biology of *T. palmi* (which was identified then as *Thrips tabaci* Lindeman) on watermelon and muskmelon. He found that the species reproduces parthenogenetically, completing development in 13 days on average. The adults live for 2-18 days and fecundity ranges from 6 to 38 eggs. The host plants he observed were amaranth, castor, corn, eggplant, potato, okra, rice, sweet pepper, soybean, winged bean and tomato.

Calilung (1990) reared T. *palmi* on potato, cucumber, eggplant, watermelon, cotton and pepper to determine the possible existence of biotypes. She observed the longest average developmental period (15.0 days) on pepper and the shortest (11.2 days) on watermelon. The highest fecundity (15.6 eggs) and longest adult life (17.4 days) were recorded on watermelon also. This could be one of the reasons for the fast thrips population buildup and very severe damage on watermelon as reported by many farmers. Adult thrips lived for the shortest period on pepper (3.9 days) and did not reproduce. When the thrips were offered a choice among the six crops, they showed a lower preference for cotton and pepper compared with the other four hosts, potato, eggplant, cucumber and watermelon, which were equally preferred. The researcher was able to collect *T. palmi* from 16 species of crops and weeds, including those reported by Palacio in 1978.

For the natural enemies, Palacio (1978) reported two chalcid parasites (Hymenoptera:Eulophidae) and one predator *Tapinoma philippinensis* Donisthorpe (Hymenoptera:Formicidae). In addition, Calilung (1990) reported the anthocorid *Orius tantillus* Motschulsky, lygaeid *Geocoris* sp., mirid *Campylomma livida* Reuter, six species of spiders (*Neoscoma fraatensis*, *Thomisus* sp. n.r. *labefactus*, *Conopistha* sp. n.r. *bonadea*, *Leucauge* sp., *Oxyopes salticus* and *Argyrodes* sp.), and five species of *Amblyseius* (*A. lenis* Corpuz and Rimando, *A. imbricatus*, *A. assisticus* (Evans), *A. longispinosus*, *A. calorai* Corpuz and Rimando, and *A. ovalis* Evans).

Pest management

Chemical control. The technology guide, the Philippines Recommends for White Potato, published by the Philippine Council for Agriculture and Resources Research and Development (PCARRD) in 1979 prescribes the following insecticides for thrips control: deltamethrin (Decis), fenvalerate (Sumicidin), monocrotophos (Nuvacron, Azodrin), carbofuran (Furadan) and oxydemetoxmethyl (Metasystox). The last two are specifically for seed potato production. The other publication Lowland Potato Technoguide, also published by PCARRD (1985) recommends profenofos + cypermethrin (Polytrin C), profenofos (Selecron), monocrotophos, methamidophos (Tamaron), methiocarb (Mesurol), chlorfenvinphos (Birlane) and formebanate hydrochloride (Dicarzol). The application rate and interval given in the container label of each pesticide is recommended also. However, several cases of unsatisfactory control of thrips on potato and watermelon have been reported by farmers, suggesting the need to improve the current recommendations.

Rejesus et al. (1986) implemented a 4-year project on management of insect pests of watermelon with emphasis on thrips. It covered chemical control, cultural management practices and a survey of natural enemies. The insecticides tested are listed in Table 1. Results of five evaluation experiments conducted in series, to follow up the most promising entry in the preceding test, showed that chlorpyrifos + BPMC (Brodan) to which a sticker was added and carbofuran plus a sticker, were the most effective in reducing the thrips population. With these pesticides, it was feasible to lengthen the time interval between applications from the usual 7 days to 18 days, thus reducing costs and hazards to nontarget organisms. However, according to vegetable farmers, field technicians and researchers, these are not among those more commonly used by farmers.

Topping the list of pesticides most sought by farmers for thrips control on different vegetable crops is profenofos + cypermethrin (Polytrin C). This is claimed to be the most effective, but it is not always available to interested users. Thus the farmers turn to the more readily procured insecticides like methamidophos, profenofos, methiocarb, monocrotophos, deltamethrin, dimethrin, formetanate hydrochloride, cypermethrin, endosulfan and azinphos-ethyl. The last two pesticides are commonly used against other insect pests, and are among the more readily available ones.

Cultural management practices. Rejesus et al. (1986) also found that mulching watermelon fields with rice straw or hog manure reduced the thrips population significantly, the ground cover possibly interfering with the process of thrips pupation in the soil. The second cultural management practice contributing to reduction in pest population in potato fields, based on farmers' experience, is overhead irrigation that can dislodge thrips from the leaves. The third is early planting of potato. In the northern part of the Philippines where the onset of the dry season is around October, land preparation can be done early to allow planting in late November or early December. This makes possible harvesting of the crop before the occurrence of the peak thrips population which is usually in March.

Table 1. List of insecticides evaluated against *T. palmi* and *A. gossypii*, 1983-86 (Rejesus et al. 1986).

Common name	Brand name and formulation	Dosage used (% kg a.i./ha)
Formetanate	Dicarzol EC	0.075
Metamidophos	Tamaron EC	0.045
Permethrin	Ambush EC	0.005
Oxydemeton	Metasystox EC	0.035
Bendiocarb	Garoox EC	0.035
Carbofuran	Furadan 3G	1.0
Diazinon	Diagran 5G	1.0
Carbosulfan	Marshal 5EC	0.10
Cypermethrin	Cymbush 5EC	0.005
Methiocarb	Mesurol EC	0.075
Acephate	Orthene EC	0.06
Chlorpyrifos + BMPC	Brodan 31.5EC	0.075
Buprofezin	NNI 750 WP	0.05

Biological control. A number of arthropods that prey on *T. palmi* were enumerated earlier, and mention was made about the tremendous increase in the thrips population following repeated pesticide application, suggesting a significant controlling effect of natural enemies. Obviously, the control agents are reduced significantly, if not eliminated, by the insecticides applied. In spite of this probable effective control factor, studies on biological control have not progressed satisfactorily because of financial constraints. Nonetheless, some relevant basic information, in addition to that already given, has been generated by researchers.

Rejesus et al. (1986) reported that *O. tantillus* was the most predominant natural enemy preying on nymphs and adult thrips on watermelon. Its average developmental period is 16.5 days. Mituda and Calilung (1989) also found that the developmental periods of the male and female *O. tantillus* were 14.8 and 16.5 days, respectively. At each nymphal instar, the males and females have essentially the same predatory capacity, increasing with each more advanced instar, and consuming more than 200 individual thrips throughout its lifetime. The maximum predatory capacity of the adult bug is 19-20 adult thrips/day.

This shows the potential of the bug as a biological control agent of *T. palmi*. The same authors were able to rear the *T. palmi* predator successfully also on *Heteropsylla cubana* (Crawford), *Corcyra cephalonica* (Stainton), *Helicoverpa armigera* (Hübner) and *Aphis gossypii* Glover.

Mituda and Calilung (1989) also studied the life cycle and predation of *Amblyseius* sp. on nymphs of *T. palmi*. The average total developmental period is 4.7 days. The adult predatory mite consumes 2-7 *T. palmi* nymphs/day and prefers first instar preys, but also attacks larger nymphs. The observed prey consumption of the other predators is 1-5 thrips/day for *Campylomma* sp., and 8-25 thrips/day for the spider *Conopistha* sp. Both predators feed on nymphs and adult thrips.

An important ecological observation was reported by Calilung and Quimio (1988) that has relevance to proper timing of release of biocontrol agents or application of other measures. Results of their 3-year study showed that T. *palmi* egg-count on watermelon was highest at 60 days after planting (DAP) and lowest at 80 DAP. The initial infestation was noted at 15-16 DAP, reaching a population peak at 40-60 DAP, but receding as early as 64 DAP to as late as 80 DAP. The total population of all the predators at any given time was usually low compared to that of *T. palmi*, but generally followed the same pattern.

Host plant resistance. The available potato germplasm at IPB, and at the International Potato Center (CIP) Regional Station for Southeast Asia based in the Philippines, has been evaluated for thrips resistance with the financial support of the International Potato Center based in Lima, Peru. Significant differences in the *T. palmi* damage sustained by the germplasm entries were observed (Bernardo and Lit 1989; Bernardo and Eusebio 1990), suggesting different tolerance levels. Leaves of some varieties remained green as viewed from the upper surface in spite of thrips damage on the lower surface. Other entries had very extensive leaf bronzing, turning brown later and eventually drying. The two serious problems encountered in varietal evaluation at low-elevation areas were difficulty in (1) mass-producing the thrips year-round under laboratory conditions, and (2) propagating the selected germplasm entries. High thrips populations can be maintained on eggplant seedlings (used instead of potato for economic reasons) in a screenhouse with natural ventilation when the temperature does not get above 32°C (Bernardo and Eusebio 1989) but not during the summer months of April-July. Also, the entries selected during field evaluation at the regular cropping season (late November to mid March) had to be taken to a highland research station for propagation so that enough planting materials can be produced for verification trials. These two problems cause considerable delay in the varietal screening work undertaken in the Philippines in collaboration with CIP.

Research Needs for the Development of Management Programs Against Thrips on Vegetables

Two project proposals to follow up some important initial research findings are being planned. One is on assessment of the potential of *O. tantillus* as a control agent and the other is on integration of some control tactics against thrips and analysis of the morphological and biochemical aspects of potato resistance.

Other studies in this area are urgently required in the Philippines: (1) the identification of all other thrips species attacking vegetable crops, and determination of their host ranges and natural enemies; (2) the ecological relationship between thrips and other arthropod pests that infest the same crop simultaneously or in succession; and (3) the selectivity of the commonly used pesticides to the natural enemies of T. *palmi.*

All of the research results reported earlier have been generated by researchers of the College of Agriculture, University of the Philippines at Los Baños. Although crop protection studies on vegetables are being pursued extensively by researchers of Benguet State University in the mountainous province of Benguet, these are centered on other pests because thrips infestations are usually not serious in high-elevation areas.

References

Bernardo, E. N., and Eusebio, J.E. 1989. Management of thrips and mites attacking potato in the lowland. Study 3. Resistance of potato germplasm to thrips and mites. Progress Report for 1989. Submitted to the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA). College, Laguna, Philippines.

1990. Management of thrips and mites attacking potato in the lowland. Study 3. Resistance of potato germplasm to thrips and mites. Progress Report for 1990. Submitted to SEARCA, College, Laguna, Philippines.

Bernado, E.N., and Lit, M.C. 1989. Resistance of selected vegetable crops to important arthropod pests. Annual Report for 1987. Institute of Plant Breeding, College of Agriculture, University of the Philippines at Los Baños, College, Laguna, Philippines.

Calilung, V.J. 1990. Management of thrips and mites attacking potato in the lowland. Study 1. Identity, biology, host range and natural enemies of potato thrips. Terminal Research Project Report. 25 p.

Calilung, V.J., and Quimio, G.M. 1988. Suppression of *Thrips palmi* Karny by natural enemies. Research Terminal Report. UPLB-PCARRD-ASSP Project No. 89-384-21. 73 p.

Mituda, E.C., and Calilung, V.J. 1989. Biology of *Orius tantillus* (Motschulsky) (Hemiptera:Anthocoridae) and its predatory capacity against *Thrips palmi* Karny (Thysanoptera:Thripidae) on watermelon. The Philippine Agriculturist, 72(2), 165-184.

Palacio, I. P. 1978. Biological study of *Thrips tabaci* Lindeman (Thripidae:Thysanoptera) on muskmelon and watermelon. Undergraduate thesis. Dept. of Entomology, College of Agriculture, UPLB, College, Laguna, Philippines.

Rejesus, B.M., Malayba, M.T., Javier, P.A., Saavedra, N.T., Palacio, I.P., and Navasero, M.V. 1986. Management of insect pests of watermelon with emphasis on thrips. Terminal Report. UPLB-PCARRD Project No. 34-264-21.

Discussion

Y. Hirose: Does *Thrips palmi* attack tomato in the Philippines? In Japan, such attacks are unknown.

E.N. Bernardo: Yes, but the more serious species is *Megalurothrips usitatus*.

K. Bansiddhi: Do thrips outbreaks occur in potato grown in the highlands?

E.N. Bernardo: No, not serious as in the lowlands, especially in the central and southern part of Luzon island.

N.T. Chang: Is the damage to crops in the field caused by thrips only, or is it combined damage of thrips and virus they transmit?

E.N. Bernardo: We did not notice serious virus infection. There was extensive leaf bronzing and so we feel quite certain that death of the plants or drying of the leaves was due more to thrips feeding.

Fauziah Hj Ismail: How justified is it to use insecticides such as profenofos, cypermethrin or methamidophos since those chemicals have pre-harvest interval (PHI) less than 7 days?

E.N. Bernardo: The recommendation for pesticide application is 2- week intervals but when the farmers see the uncontrolled population buildup, they are tempted to apply the chemical at a much shorter time interval.

N.S. Talekar: Some predators are important in thrips control; will the rice straw or other plant refuse mulching help in preserving predators like spiders and help in thrips control?

E.N. Bernardo: I believe so although we do not have hard data to support this. It has been found that mulching results in reduced thrips population which has been attributed largely to interference with pupation of *T. palmi* in the soil. It is highly possible that soil-inhabiting predators are favored also.

N.S. Talekar: We often observe leaf crinkling in mungbean and pepper associated with thrips. It is often confused with virus diseases. Does that occur in potato? Can that be used in damage rating for host-plant resistance screening?

E.N. Bernardo: Leaf crinkling on potato is not as extensive as in pepper and so I have been using leaf bronzing as an indicator of varietal resistance in potato.

N.S. Talekar: Is there any artificial diet for thrips? How can we rear large numbers of thrips for host-plant resistance work?

E.N. Bernardo: I am not aware of any artificial diet for thrips. On potato I have been evaluating germplasm in the field with proper timing of planting (when thrips population is expected to be high). Instead of planting in late November or early December, I plant in mid or late January to take advantage of high thrips population in late February to March. High thrips population can be produced in the screenhouse on eggplant seedlings except during hot summer months.

S. Sastrosiswojo: Is the thrips resurgence only due to indirect effect of insecticide sprays killing the natural enemies or because of the direct effects?

E.N. Bernardo: We have not looked into this problem systematically, but based on predator counts in sprayed and unsprayed eggplant fields, we are inclined to believe that predators are important controlling factors that are adversely affected by the pesticides applied.

J. Vos: With so much attention to natural enemies, have you come across entomophthora fungi reducing the thrips during wet seasons, perhaps explaining thrips seasonality?

E.N. Bernardo: We have not looked closely at the existence of entomophthora fungi.

Thrips on Vegetables in Indonesia

Sudarwohadi Sastrosiswojo
Lembang Horticultural Research Institute
Jl. Tangkuban Parahu 517
Lembang 40391, P.O. Box 1586 Bandung
Indonesia

Abstract

Thrips are serious pests of vegetables such as chili, onion and potato in Indonesia. *Thrips tabaci* Lind., *T. palmi* Karny and *T. parvispinus* Karny are the major thrips species on vegetables in Indonesia. Although the thrips problem is becoming more important, not many studies have been done in Indonesia. A review of the research carried out so far, possible control measures, current status and constraints are described.

Introduction

Vegetable crops are important in Indonesia because of their high nutritional value and contribution to agricultural industries. Commercial vegetable plantings of potato, tomato and cabbage are common in the highlands, whereas chili (*Capsicum annuum*), shallot (*Allium* sp.), cucumber and yardlong bean are usually grown in the lowlands. The average yield of vegetables in Indonesia was relatively low (3.1 t/ha) in 1984, but increased to 5.0 t/ha in 1987 (Table 1). There are still many constraints that need to be resolved to increase production, including seed supply (quantity and quality), pests and diseases, and adverse environmental conditions.

Insect pests and diseases are considered to be the most important factors limiting the productivity of vegetables. Sucking insects such as thrips, aphids and mites may inflict damage to vegetable crops either directly by reducing plant vigor or indirectly by vectoring virus diseases.

Economic Importance and Bioecology of Thrips

Economic Importance

Thrips are polyphagous insects and serious pests of vegetables such as hot pepper, shallot and potato. Data on crop losses due to thrips in Indonesia are not available. In India, Butani (1976) reported that thrips may cause 30-50% crop losses and are responsible for transmitting leaf curl disease on chili. In lowland areas of Central Java, young shallot plants are often destroyed by heavy infestations of *Thrips tabaci* (Lindeman), especially during the dry season.

Thrips usually feed on the lower surface of leaves. The cell contents are rasped and sucked from the lower mesophyll. As a result air spaces develop in this tissue and the leaf becomes distorted. Damaged leaves frequently have a silvery sheen and they may bear small spots of fecal matter. Feeding damage on cabbage or potato leads to russeting or bronzing of leaves; young plants are especially susceptible. Heavy thrips attacks can cause sufficient leaf damage to kill young onions (Kranz et al. 1978).

In Indonesia, *Thrips* (= *Isoneurothrips*) *parvispinus* is a serious pest of chili. Damage becomes apparent on the lowest leaves and spreads upwards during the growth period of the plant. Numerous silvery spots appear near the veins, often merging, resulting in white veins speckled with excrement. The silvering, scarring and distortion of leaves and fruit caused by feeding, and later discoloration due to excrement, and the growth of moulds are usually easy to detect. However, the economic importance of these symptoms is more difficult to assess, especially if coupled with virus attacks.

Table 1. Vegetable production in Indonesia, 1984 and 1987.

Crop	Harvested area ('000 ha)		Total production ('000 t)		Yield (t/ha)	
	1984	1987	1984	1987	1984	1987
Shallot	57.5	65.8	295.1	397.1	5.1	6.0
Garlic	9.1	16.1	47.5	102.0	5.2	6.3
Leek	23.7	27.0	107.8	181.5	4.5	6.7
Potatoes	33.0	33.6	371.5	378.9	11.3	11.3
Cabbage	40.0	49.6	584.1	840.4	14.6	16.9
Carrot	6.8	11.9	54.2	138.0	8.0	11.6
Ch. cabbage	23.9	29.4	153.0	234.1	6.4	8.0
Radish	3.5	4.0	21.7	32.3	6.2	8.1
Legumes	288.9	174.7	427.5	345.9	1.5	2.0
Chilies	243.2	192.7	313.7	470.4	1.3	2.4
Tomatoes	41.8	41.0	138.1	208.7	3.3	5.1
Eggplant	64.9	55.1	139.0	187.6	2.1	3.4
French bean	27.7	26.7	83.3	118.6	3.0	4.4
Cucumber	54.1	58.9	220.2	323.3	4.1	5.5
Chayote	19.1	24.9	63.8	200.1	3.3	8.0
Kangkong	35.2	32.3	74.8	172.8	2.1	5.3
Amaranthus	32.0	32.5	53.7	96.0	1.7	3.0
Others	38.8	22.5	89.7	28.5	2.3	1.3

Source: Directorate of Production for Horticulture (1989).

Biology and Ecology

Several thrips species are important as vegetable pests in Indonesia: onion thrips (*Thrips tabaci* Lind.), potato thrips (*Thrips palmi* Karny), *Chaetanaphothrips* (= *Scirtothrips*) *signipennis* (Bagn.) on chili, tobacco thrips or *Thrips* (= *Isoneurothrips*) *parvispinus* (Karny) on chili and cucumber, and *Frankliniella* sp. on legumes (Dammerman 1929; Kalshoven 1981).

Thrips tabaci: *T. tabaci* is a cosmopolitan and polyphagous species. It is found on shallot, leaf onion, leek and garlic. Other food plants include chili, potato, tomato, melons and amaranth.

The development period of *T. tabaci* on onions may be completed in 7-12 days. The egg production is about 80 (Kalshoven 1981). Lall and Singh (1968) reported that females laid an average of 15.6 eggs in clusters inside the epidermal layer of onion leaves, and adult females lived an average of 19.7 days.

Since the life cycle of *T. tabaci* is relatively short and a single female produces 80 eggs, multiplication can be very rapid. The adult thrips can live for 20 days. Parthenogenesis is a common phenomenon. The eggs are laid singly in the leaf tissue and the incubation period is 3 days.

In addition to direct feeding damage, *T. tabaci* also transmits tomato spotted wilt disease to several crops (Kranz et al. 1978; Mughal 1985; Atherton and Rudich 1986).

Thrips palmi: *T. palmi* is distinguished from other species by its bright citron-yellow color with the legs having a lighter hue (Dammerman 1929). In the 1980s it was discovered that *T. palmi* had become an important pest of potato in the highlands of Java and Sumatera. The damage caused by this insect is very serious, especially in the dry season, and little is known of the bioecology of this pest in Indonesia.

Thrips parvispinus: The older Indonesian literature refers to 'chilli thrips' as *T. tabaci*. Recently, however, proper identification has been done in the Netherlands, and the name of the species has been corrected to *T. parvispinus*. In India, the chili thrips is known as *Scirtothrips dorsalis* Hood (Butani 1976; Amin 1979; Manoharan et al. 1982).

Among all species of thrips in Indonesia, *T. parvispinus* is considered to be the most damaging pest of chili in the country. Several studies in 1989-90 have been devoted to this species, especially on control measures. Several rearing techniques have been tried, but none has succeeded. A simple and effective rearing technique is important for several purposes: laboratory studies, screening for host-plant resistance, biological control studies, etc. Therefore, mass production techniques for thrips should be studied further.

In 1989-90 a study on the biology of *T. parvispinus* on hot peppers was conducted in the lowlands. The preliminary results indicate that this species can cause yield losses of 22.8%. The population density of thrips in profenofos (0.2% a.i.) treated and untreated plots did not show significant differences. Physical factors such as rainfall did not seem to affect the thrips population. An effective insecticide against thrips will be sought and used in a future study.

Different colors of sticky-board traps have been studied to monitor thrips populations. Results of this study are reported elsewhere by Vos (this volume). Lippold (1975) reported that yellow and white boards are extremely effective for trapping predominantly sucking pests, including thrips.

Control Practices

Cultural Practices

Irrigation or flooding can be used to destroy thrips which spend pupal stage in the soil (Lewis 1973). In rice-based areas, farmers usually grow chili and shallot after rice. By watering plants once or twice daily, the population of thrips can be reduced.

In Java, thrips damage to shallot can be reduced by planting shallot in the second half of April or the first half of May.

Aluminum foil mulches may deter flying insects such as aphids and thrips from landing on plants (Lewis 1973). The mechanism of repelling the insects is perhaps associated with a disturbance in the orientation prior to landing, caused by the presence of a bright, highly reflective surface beneath them. The use of black plastic mulch has proved effective in suppressing the population of thrips on chili.

Chili seedlings are highly susceptible to thrips attack. Therefore raising the seedlings in an isolated place (e.g. in a screenhouse) will protect them.

Resistant Varieties

More than 600 cultivars of chili are grown by farmers in Indonesia. Preliminary screening for resistance to thrips has been done in the screenhouse. Some cultivars (e.g. Tangerang, Bojonegoro and Serang) were less susceptible to T. *parvispinus*. In India, Rao et al. (1984) reported that chili varieties X197, X203 and X180 were the least susceptible to *Scirtothrips dorsalis*, and produced the highest yield. Chili cultivars LIC 8, Pant C-1 and LEC 7 were also reported to be resistant to thrips (Sanap and Nawale 1985).

Biological Control

Two species of predators, coccinellid beetle and larvae of chrysopid (lacewig), were frequently found in our bionomic study of thrips on chili. However, it seems that these predatory insects were not very effective.

Lewis (1973) gives a long list of natural enemies of thrips. There are 43 species of parasitoids, 169 species of predatory mites and 30 species of predatory thrips in the world reported to be natural enemies of thrips and/ or mites. Only a few of these are effective against thrips on vegetables. These include *Amblyseius cucumeris* and *A. barkeri* (= *A. mokenziei*). Both predatory mites which are commercially available in Europe for the control of *T. tabaci* and *Frankliniella occidentalis* (IPM Practitioner 1988). In 1990 efforts were initiated to introduce *A. cucumeris* from the Netherlands into Indonesia. The permit to introduce the predator has not yet been granted by the Indonesian government, so the biological control program of thrips has not yet been started.

Anthocrid species *Orius minutus* (L.) was known mainly as a predator of the tetranychid mite *Tetranychus urticae* Koch. *Orius minutus* showed a pronounced preference for thrips, in spite of the presence of the mite (Ramakers 1978).

Chemical Control

Conventional chemical insecticides remain one of the most important tools to combat thrips. The recommended insecticides are quinalphos, endosulfan, mercaptodimethur, acephate, formetanate hydrochloride and cypermethrin. A survey of agrochemicals used by the farmers in the lowland vegetable-growing areas revealed that farmers applied at least 16 sprays (at 3-4-day intervals). The insecticides were used in a mixture of three or more chemicals. It is estimated that the cost for insecticide usage on chili was about 51% of the total variable production cost. In the highlands, the situation is not much different. It is therefore very important to convince the farmers to look for alternative control methods.

Control Threshold

There are no statistics available on control threshold for thrips in Indonesia. Studies on this are urgently needed. Raheja (1973) reported that a population of five *T. tabaci* per onion plant was considered critical, requiring spraying. No other information on threshold levels for thrips is found in the literature.

Integrated Control Program and Constraints

At present the control of thrips in vegetables still relies heavily on insecticides, despite the disadvantages of this practice. However, there is no other control strategy available to combat thrips in vegetables. Although the thrips problem has become serious, very little research has been done to control this pest. This situation has changed recently, particularly for chili in the lowlands.

It may be too early to propose the development and implementation of an IPM program on thrips in vegetables, because of the lack of information on the biology of thrips and their natural enemies, selective insecticides, control threshold and other important components of IPM for thrips. It is, however, important to set up collaborative research and to exchange information among the scientists in Southeast Asia, with AVRDC playing an important lead role in the development and implementation of an IPM program on thrips in vegetables in the region.

References

Amin, P. W. 1979. Leaf curl disease of chili peppers in Maharashtra, India. PANS, 25(2), 131-134.

Atherton, J. G., and Rudich, J. (ed.) 1986. The Tomato Crop. Chapman and Hall. London and New York 414-415.

Butani, D. K. 1976. Pests and diseases of chillies and their control. IARI (Indian Agricultural Research Institute). Pesticides (India), 10(8),38-41.

Dammerman, K. W. 1929. The Agricultural Zoology of the Malay Archipelago. J. H. de Bussy Ltd., Amsterdam, 215-217.

Directorate of Production for Horticulture. 1989. Improved Production of Vegetables in Indonesia. 29 p.

IPM Practitioner. 1986 Update: Biological Control of Insects in the Netherlands. Special Biocontrol Issue, 10(4), 5 p.

Kalshoven, L. G. E. 1981. Pests of Crops in Indonesia (Revised and translated by P.A. van der Laan). P. T. Ichtiar Baru-van Hoeve, Jakarta, 83-88.

Kranz, J., Schmutterer, H., and Koch, W. 1978. Diseases, Pests and Weeds in Tropical Crops. John Wiley & Sons. Chichester, New York, Brisbane and Toronto, 280-283.

Lall, B. S., and Singh, L. M. 1968. Biology and control of the onion thrips in India. J. Econ. Entomol., 61(3), 676-679.

Lewis, T. 1973. Thrips. Their Biology, Ecology and Economic Importance. Academic Press, London and New York, 349 p.

Lippold, P. C. 1975. Use of colored sticky board traps in insect surveys. Plant Prot. Service Technical Bull. (FAO), Bangkok. No. 29, 60 p.

Manoharan, V., Gopalan, M., Ramalkrishnan, C., Rangasami, P., and Shanmugavelu, K. G. 1982. Evaluation of preference of thrips (*Scirtothrips dorsalis* H.) on chilli accessions. South Indian Horticulture (India), 30(2), 155.

Mughal, S. M. 1985. Viral diseases of tomato and their control. Progressive Farming (Pakistan), 5(2), 20-23.

Raheja, A. K. 1973. Onion thrips and their control in Northern Nigeria. Samaru Agric. Newsletter (Nigeria), 15(2), 84-86.

Ramakers, P.M.J. 1978. Possibilities for biological control of *Thrips tabaci* Lind. (Thysanoptera: Thripidae) in glasshouses. Med. Fac. Landbouw. Rijksuniv. Gent., 43/2, 463-469.

Rao, D. M., Ahmed, K., and Murthy, N. S. 1984. Chilli varieties and their reaction towards pests. Indian Cocoa, Arecanut and Spices Journal (India), 7(4), 118-119.

Sanap, M. M., and Nawale, R. N. 1985. Reaction of chilli cultivars to thrips and mites. J. Maharashtra Agric., Univ. (India).

Discussion

Fauziah Hj Ismail: With regard to cultural control by using mulches: (1) How economic is it in chili production to use aluminum foil compared to black plastic? (2) What is the perception of the farmers regarding the use of mulches since these materials are very costly?

S. Sastrosiswojo: I think black plastic is much cheaper than aluminum foil. Some private companies in Indonesia use black plastic to control thrips on chilis. It is true that mulches are considered expensive for smallholders. Instead of black plastic they use rice straw.

S. Poonchaisri: Do you have only one species of thrips damaging chili? In Thailand we have two species, on leaves *Scirtothrips dorsalis* and in the flower *Thrips parvispinus*. *T. parvispinus* is found in many crops but only on the flowers.

S. Sastrosiswojo: We have two species of thrips, *T. palmi* and *T. tabaci*, and possibly *T. parvispinus*, but more detailed studies are still needed to prove whether chilis are their host plant. I think you are right; there might be misidentification of the thrips species.

S. Poonchaisri: Have you ever found males of *T. tabaci* in Indonesia?

S. Sastrosiswojo: We haven't studied the sex ratio of *T. tabaci*. However, I assume that male thrips are very rare under natural conditions.

Thrips on hot peppers in Java, Indonesia

J. G. M. Vos*, S. Sastrosiswojo**, T. S. Uhan** and W. Setiawati**

*Associate Expert
Integrated Crop Management
Project ATA-395
P.O. Box 1427, Bandung 40014
Indonesia

**Research Staff
Plant Protection
Lembang Horticultural Research Institute (LEHRI)
Lembang, West Java
Indonesia

Abstract

Thrips is one of the major pests of hot pepper (*Capsicum* spp.) in Indonesia. The thrips species commonly found on hot pepper in Java has been identified as *Thrips parvispinus* Karny. Thrips damage is more severe during the dry season. In chemical control trials, yield losses were estimated at more than 20%. Since 1989 experiments have been carried out on chemical and cultural control and screening for host-plant resistance. A technique using Pasteur disposable pipettes was developed to screen insecticides under controlled laboratory conditions. In field experiments four different monitoring methods were used. Insecticide screening in the field and the laboratory revealed that Polo (diafenthiuron) is most effective in controlling thrips. For biological control, the predatory mite *Amblyseius cucumeris* is a possible thrips-controlling agent, but introduction into Indonesia has not yet taken place. Screening for resistance has been delayed due to difficulties with rearing thrips under controlled conditions. Preliminary experiments have shown that three local cultivars (Tanggerang, Bojonegoro and Serang) were less preferred by thrips under screenhouse conditions. Mulching with light-reflecting plastics has proved to be a successful cultural practice to delay buildup of thrips populations: thrips damage is reduced significantly until 3 months after planting. Another cultural measure under investigation is the raising of seedlings under screen cover. Suggestions are made for future research concerning thrips biology and control.

Introduction

Among the major commercial vegetables grown in Java, Indonesia, hot peppers (*Capsicum annuum* L. and *C. frutescens* L.) form the most important crop in terms of hectarage and production value. In 1988 the area under hot pepper was 95,700 ha with an average yield of 3.3 t/ha (Central Bureau of Statistics 1988). About 79% of the hot pepper is cultivated in the lowlands (below 450 m). The important lowland hot pepper production centers on the island of Java are shown in Fig. 1. Most cultivated hot pepper cultivars are local strains that are multiplied by farmers themselves.

Recent surveys in main hot pepper-growing areas have shown the importance of hot pepper pests and diseases, which are listed in Table 1.

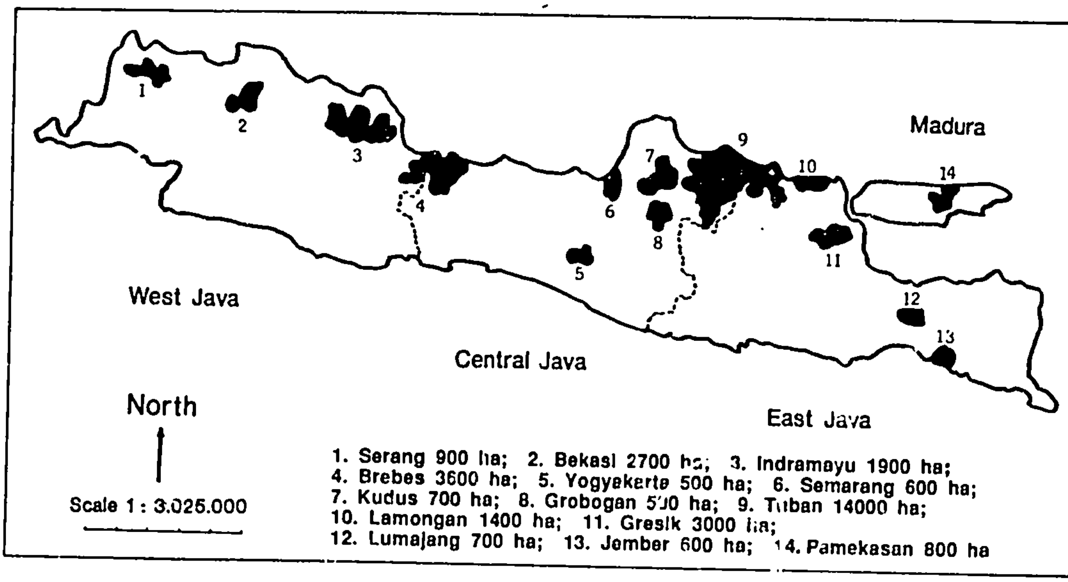

Fig. 1. Hot pepper production centers below 450 m in Java and Madura, 1987 (Source: LEHRI Vegetable Databank 1987).

Table 1. Major pests and diseases of hot pepper in major production areas in Java, Indonesia, encountered during field surveys in 1989-91.

Major pests:	Thrips (*Thrips parvispinus*)
	Mites (*Polyphagotarsonemus latus*)
	Cicadellids
	Dacus fruitfly (*Dacus dorsalis*)
	Armyworm (*Spodoptera litura*)
	Aphids (*Myzus persicae*)
Major diseases:	Viruses (CVMV, CMV and others)
	Anthracnose fruit rot (*Colletotrichum capsici* and *C. gloeosporioides*)
	Cercospora leaf spot (*Cercospora capsici*)

Identification of thrips

In the first half of this century, an unidentified thrips species was reported as a harmful agent of hot pepper in Indonesia. At that time, onion thrips, identified as *Thrips tabaci* Lind., were believed to have potential of attacking hot pepper plants as well (Kalshoven 1950). More recently, in November 1988, thrips were collected from hot pepper at four locations and identified by the Phytopathological Service (PD), Wageningen, Netherlands (Table 2).

The most commonly found thrips species was *Thrips parvispinus* Karny. According to Vierbergen (PD Netherlands, pers. comm. 1989) the following thrips species also occur in Java: *Thrips hawaiiensis*, *T. florum* and *T. orientalis*, which live in flowers and are hard to distinguish from *T. parvispinus*. The other identified thrips, *Haplothrips gowdeyi* Franklin, is a polyphagous flower-inhabiting species, generally occurring in the tropics. *Thrips parvispinus* has a wide host range, including several important crops (tobacco, coffee, *Ipomoea* spp., *Vigna* spp., *Capsicum* spp., cucumber). It has been found in Thailand, Indonesia (Sumatra and Java), Australia (Queensland), and Papua New Guinea (Jacot-Guillarmod 1975).

Table 2. Identification of thrips species, collected at different locations in Java, Indonesia, in 1988.

Province	Location	Elevation	Thrips species
Central Java	Klampok	10 m	*Thrips parvispinus* Karny
West Java	Cikampek	45 m	*T. parvispinus*
West Java	Lembang	1200 m	*T. parvispinus, Haplothrips gowdeyi* Franklin
West Java	Sukamandi	15 m	*T. parvispinus*

Thrips on potatoes in Pacet (West Java) have been identified by CAB International Institute of Entomology in UK as *T. parvispinus* (collected at 800 m) and *T. palmi* Karny (collected at 1400 m) (Potts, CIP Indonesia, pers. comm. 1989).

Geographical distribution and seasonality

During visits to hot pepper production areas (Fig. 1), thrips were almost always found. Thrips is a very problematic pest, especially in the Brebes area (Central Java) and, to a lesser extent, in the Indramayu area (West Java).

It was discovered that thrips is not a key pest in areas where pesticide use is still limited (one single compound application every 2-3 weeks). In the Brebes and Indramayu areas, pesticides are often applied as mixtures of two or more compounds with an intensity of 1-3 applications a week. Besides that, in Brebes the fertilizer input is high also (about 1000 kg N/ha, 400 kg P/ha and 250 kg K/ha).

In the Brebes area, hot peppers are grown during the dry (April-October) and wet season (November-March). It was learnt from hot pepper field trials that the thrips pest is more severe in the dry rather than the rainy season. Possible explanations for this seasonality are wash-off by heavy rain showers and higher mortality caused by increased activity of insect-pathogenic fungi under humid conditions. Kalshoven (1950) mentioned another reason: thrips that pupate in soil have problems penetrating dense soil, a situation usually occurring after heavy rains. He reported *T. parvispinus* as a tobacco pest in Central and West Java, that pupates in the soil. Lewis (1973) stated that soil-dwelling stages of thrips are vulnerable to very high or low soil moisture.

Feeding behavior of thrips and symptomatology

The feeding behavior of thrips is still not well understood. Methods of feeding have been described as puncturing epidermises and sucking cell contents, or as rasping of leaf tissues and sucking exuding saps (Lewis 1973).

Thrips especially affect young leaves. The undersides of these leaves first show silvery, irregular stains, due to mechanical feeding damage. The leaves react with blistering and upward curling. After some time the silvery stains turn light brown and show small black specks. Thrips feed on leaves during the night; during the daytime most thrips are found in hot pepper flowers. It is suggested that premature flower drop is caused by thrips feeding on stamen or pistil.

Economic importance

Few data are available on the economic importance of thrips on hot pepper in Indonesia. Crop losses are difficult to assess, because pests other than thrips (especially mites) and diseases (especially viruses) are hard to control in the open.

In 1989, an insecticide screening trial in Tanjung (Central Java) revealed an estimated yield reduction of 20% due to combined thrips and mite attack. This yield reduction was calculated by comparing the yield of the most effective treatment with the control. This treatment, however, did not fully control thrips.

During another trial in 1989 in Klampok (Central Java) an average thrips population of 27/plant was found in the plots that were not treated with insecticides. In the treated plots the population was reduced to an average of 19 thrips/plant. The yield differences between treated and untreated plots were not significant.

In 1990, a yield reduction of 23% due to thrips and aphid attack was observed in a field trial with insecticide-treated vs untreated plots in Kramat (Central Java). Weekly observations showed an average of 12 thrips/plant in the sprayed plots compared to 25/plant in the untreated plots.

Tomato spotted wilt virus (TSWV), a thrips-transmitted virus, has not yet been found in Java. It therefore does not play a role in increasing crop losses due to thrips.

Methodologies

Laboratory experiments

It has proved difficult to force thrips to feed on leaves under controlled conditions. Thrips are very sensitive to manipulation and environmental changes.

At LEHRI, a special laboratory method was developed for screening of insecticides. Pasteur disposable pipettes, closed on the wider end with Monodur PA 100 nylon gauze, were treated with insecticide/acetone solutions by submergence. Each product was tested in five concentrations with five replications. After drying the treated pipettes, 10 adult thrips were sucked into each pipette. The mortality was observed by using a binocular microscope. The thrips, used for this experiment, were collected in the field by sampling hot pepper flowers and were chilled for 30 min in a refrigerator for temporary reduction of their mobility.

Thrips in pipettes were sensitive to low relative humidities, so to reduce early mortality due to low RH, the pipettes had to be kept at about 80% RH.

Field experiments

Four monitoring methods were used to describe thrips population dynamics and the degree of thrips damage on hot pepper in field trials. Observations were conducted throughout the growing season.

A. *Scoring*: The following scale was developed to assess thrips damage in the field:

0 = no symptoms of thrips damage;
1 = less than 25% of the plants show mild leaf curling of top leaves;
2 = 25-50% of the plants show mild leaf curling of top leaves;
3 = 50-100% of the plants show leaf curling of top leaves;
4 = all plants show severe leaf curling of top leaves.

B. *Trapping on sticky boards*: Sticky, yellow and white boards were placed vertically in hot pepper plots once a week for 24 hours. Experimentation with size and color of these sticky boards led to the following conclusions:

- Most thrips were trapped at canopy level or just above;
- No difference was evident between the types of glue used to trap thrips: Tanglefoot, Thripstick (polybutenes) and Genap (pre-glued yellow plastic plates) all functioned satisfactorily.
- Routine use of yellow and white traps in field trials resulted in significantly more thrips trapped on white than on yellow boards. A recent experiment, comparing white, yellow, light blue, light green, dark green, red and black sticky boards, showed that light blue was the most attractive color to thrips; second and third were white and light green, respectively. In Thailand, Lippold et al. (1975) concluded that thrips, feeding on hot pepper, are more attracted by white than by yellow colored boards.

C. *Flower sampling*: During the daytime thrips can be found in pepper flowers. Sampling of thrips was therefore done by picking open flowers and storing these in a bottle with 70% alcohol. After shaking the bottle, the flowers were removed and the remaining thrips were counted by using a loupe. Significantly more adults than larvae were found in these samples. It was observed that numbers of thrips were low when sampling was carried out after heavy rains: weather conditions are of more influence than the time of the day of sampling.

D. *Plant sampling*: Plants were pulled out, transported in plastic bags and shaken on white paper. In this way, all thrips occurring on a plant could be counted.

The four described methods (A - D) cover different observations. The visual scoring method (A) describes crop reactions to an unknown number of thrips; differences between treatments in field trials can rapidly be assessed by this method. The insect trapping figures of method (B) represent the number of thrips in the air above the crop canopy; they do not represent the number of thrips on a crop. When screening pesticides, the highest number of thrips was found on traps placed in the best thrips-controlling treatment. It was concluded that thrips may be repelled by the smell of insecticides and jump or fly away from treated plants. By the time hot pepper plants produce enough flowers to use observation method (C), the crop is usually 6-7 weeks old; the initial development of the thrips population cannot be covered through this method. Besides that, sufficient plants must be available to produce the number of flowers required weekly. Method (D) is the only method that determines the number of thrips on the whole plant. However, this method is destructive and requires a large number of plants per treatment.

Results

Chemical control

From a field screening trial with 14 insecticides in the 1989 dry season in Tanjung, Central Java, it was concluded that some systemic insecticides have fair prospects for thrips control. A satisfactory level of control was achieved only by application of Polo 0.1% (a.i. diafenthiuron), but this insecticide is not yet registered in Indonesia. In that trial, adjusting spraying technique by use of a flat spray nozzle and constant pressure for an even distribution of spray solution did not improve the efficacy of insecticides due to poor penetration into the leaf canopy.

In laboratory experiments in 1990, six insecticides were tested using the described Pasteur disposable pipettes method. Experiments with other insecticides are in progress. The results of both field and laboratory experiments are presented in Table 3.

Table 3. Effect of insecticides on thrips in hot peppers, tested in a field and laboratory trial in 1989 and 1990, respectively.

Trade name	Active ingredient	Field 1989	Laboratory 1990
Curacron	profenofos	++	+
Curater	carbofuran	+++	/
Decis	deltamethrin	/	++
Fenom	cypermethrin	-	/
Kelthane	dicofol	/	-
Malathion	malathion	+	/
Meothrin	fenpropathrin	-	/
Mesurol	methiocarb	-	/
Morestan	oxythioquinox	-	/
Nogos	dichlorvos	-	/
Nuvacron	monocrotophos	-	/
Pirimor	pirimicarb	/	-
Polo	diafenthiuron	++++	+++
Supracide	methidathion	-	/
Tamaron	methamidophos	-	/
Tokuthion	prothiophos	++	-
Vydate	oxamyl	+++	/

- = no effect.
+ to ++++= increasingly effective.
/ = not tested.

Besides type of insecticide, timing and technique of spraying also influence the effect of chemical control measures. Modification of spraying technique can improve penetration of the spray liquid into the hot pepper crop. However, the coverage of undersides of leaves could only be increased by spraying with high pressure: 7 bar instead of the usual 3 bar (Stallen and Arifin 1990).

Biological control

Research on natural enemies of thrips has shown that biological control can be successful as a component of integrated pest management of thrips. Ramakers (1978) mentioned the predators *Amblyseius* spp. and *Orius minutus* L. and the pathogenic fungus *Entomophthora* spp. as possible control agents of thrips in Dutch glasshouses. Presently, predatory mites (*Amblyseius* spp.) are reared on a commercial scale and are widely applied by glasshouse vegetable growers in The Netherlands. As far as application of biological control in the open is concerned, Sureshkumar and Ananthakrishnan (1987) reported three species of polyphagous predatory thrips in India: *Erythrothrips asiaticus* Ram. and Marg., *Franklinothrips megalops* Trybom and *Androthrips flavipes* Karny. Unfortunately it was not mentioned on which crops these biological control agents were tested.

At LEHRI, no tests with biological control agents have so far been conducted. A request for the import of the polyphagous predatory mite *Amblyseius cucumeris* Oud. from the Netherlands has been submitted to the authorities.

Resistant/tolerant hot pepper cultivars

Breeding for host plant resistance or tolerance to thrips has been started in several countries. In India, Singh and Cheema (1989) reported a number of hot pepper lines and improved cultivars with varying degrees of tolerance (probably partial resistance) to thrips. In The Netherlands, research is being carried out to assess mechanisms of resistance to thrips in cucumber. The experiments are done in the laboratory, using leaf discs floating on water and young female thrips placed on the leaf discs. Attention is paid to the developmental period, reproduction rate, mortality rate, longevity and the maturation period of the offspring. Results of this research will probably be applicable to hot pepper resistance breeding as well (Mollema, CPO Netherlands, pers. comm. 1988).

In Indonesia, screening of local hot pepper accessions was started at LEHRI in 1989. Difficulties with rearing of thrips under controlled conditions caused a delay of this research activity. Until now, 57 accessions have been screened; three local cultivars, Tanggerang (LV 1125), Bojonegoro (LV 1912) and Serang (LV 1106), appeared to be less preferred by thrips under screenhouse conditions.

Cultural control

Control of thrips by means of chemicals has thus far proved to be difficult. Research on biological control and resistant cultivars is still in an early stage. Therefore, considerable attention is given to cultural practices that can suppress or delay thrips population growth. Cultural control is considered as an important component of integrated crop management. So far promising results have been achieved by application of light-reflecting plastic mulches. Raising of hot pepper seedlings under screen cover is another form of cultural control of thrips.

Light reflecting plastic mulch. Three consecutive hot pepper field trials were carried out to test different mulches at different locations during both the dry and wet season. The trials included one organic (rice straw) mulch and two plastic (white and aluminum colored) mulches. Insecticides that can control thrips were not applied in these trials. The plastic mulches consistently delayed thrips damage and thus reduced crop losses. The rice straw mulch did not affect the thrips population (Fig. 2). There are two possible explanations for the thrips-controlling effect of plastic mulches:

(1) *Distraction.* Due to the light reflection by the soil coverage, thrips may be unable to recognize host plants. Thrips are either attracted to or repelled by the light-colored soil surface. In both cases, thrips are distracted from the crop.

(2) *Exclusion of topsoil medium.* Kalshoven (1950) mentioned that *Thrips parvispinus* pupates in topsoil. In this case, pupation of thrips is interrupted by covering soil with plastic.

Besides the effect on thrips, light-reflecting plastic mulches also showed a number of other effects: delay of virus incidence, faster growth and development of the crop and increase of yield.

Protected raising of plants. By use of screen covers, hot pepper seedlings can be raised free from sucking damage. Counting thrips on sticky boards showed that large numbers were trapped in hot pepper grown in the open (on average more than 200) compared to low numbers inside a screenhouse and screen tunnel (on average less than 10) in 1 week. The mesh of the screen used for the screenhouse was 560 µm; the tunnel was covered with a screen with mesh of 240 µm. At all locations insecticides were sprayed once a week to control sucking insects. Another trial in 1990, comparison of screen-covered (nylon shrimp fish-net with mesh of 560 µm) with unprotected plant-raising in Subang, West Java, showed a significantly lower incidence of damage by sucking insects at transplanting. Insecticides for the control of sucking insects were not applied during the plant-raising period of 4 weeks.

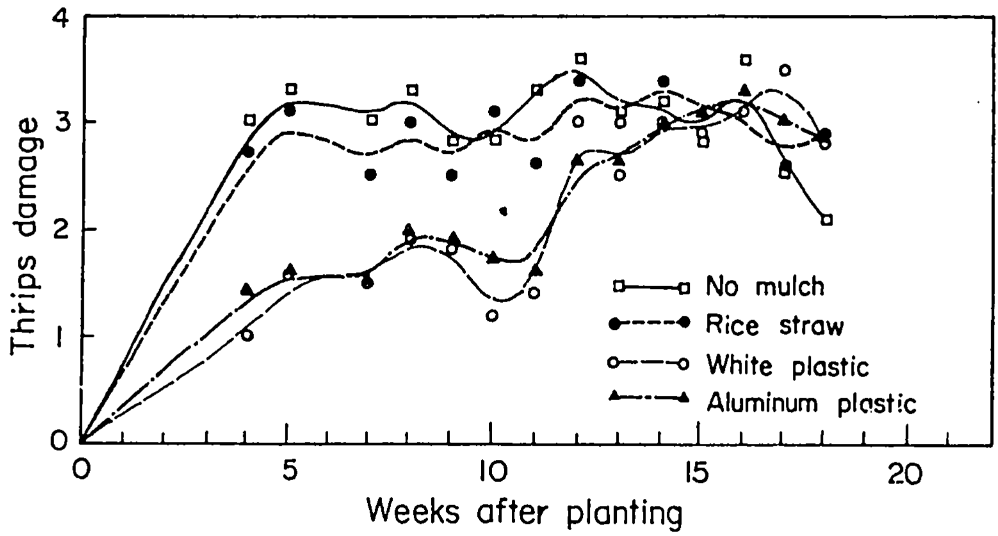

Fig. 2. Results of visual thrips damage scores in dry and wet season (1989-90) hot pepper mulch trials at LEHRI experimental sites in Brebes (Central Java; three trials) and Subang (West Java; one trial).

Discussion

It is clear that much research still has to be done concerning thrips biology and control. Attention should be paid to the following items:

Identification. In the literature, *T. parvispinus* is rarely mentioned as a hot pepper pest. In India, hot pepper thrips have been identified as *Scirtothrips dorsalis* Hood (Ananthakrishnan 1980) and in Guadaloupe as *T. palmi* (Guyot 1988). In The Netherlands, *Frankliniella occidentalis* Pergande (Mantel and Van de Vrie 1988) affects glasshouse pepper cultivation. Identification of thrips samples from all pepper production centers in Java and the other islands of Indonesia would give a more complete overview of the distribution of hot pepper thrips species.

Effects of intensive use of agrochemicals. Thrips have been found to be key pests in areas where pesticide inputs are high. This suggests that thrips have become resistant to insecticides in these areas. The mechanism of resistance is, however, still unknown. Due to intensive insecticide use, natural enemies of thrips may have disappeared. Insecticides are used for the control of both armyworm and aphids. When biological control measures are available to combat these pests, natural predators of thrips will have a greater chance of survival.

A high proportion of nitrogenous compounds makes leaf tissue a rich source of nutrients for thrips (Lewis 1973). The intensive use of nitrogen especially to fertilize hot pepper crops may increase the attractiveness to thrips. The effects of N, P and K on the susceptibility of hot peppers to thrips have to be investigated.

Seasonality. Several hypotheses have been postulated to explain the reduced thrips damage in the rainy season. Besides those, Sanap et al. (1985) stated that high temperatures and low relative humidity are favorable for thrips population growth. In laboratory experiments at LEHRI, however, thrips appeared to show high early mortalities under relative humidities below 70%. Kalshoven (1950) mentioned that high relative humidity is a prerequisite for thrips development. Further research is needed to explain seasonality effects on thrips in order to predict thrips outbreaks.

Crop losses. Until now only rough estimations have been made about the percentage of yield losses due to thrips in Indonesia. In India, Ahamed et al. (1987) calculated the average yield loss caused by thrips on hot pepper. They found a yield reduction of 21%, while the total yield reduction caused by sucking insects and mites appeared to be 34%. Also in India, Singh and Cheema (1989) reported hot pepper yield losses of 25-50% due to thrips. For assessments of damage thresholds, more detailed information is needed about damage caused by fixed numbers of thrips. These experiments must be carried out under controlled conditions.

Viruses are important causes of disease in hot peppers. It is not known if *Thrips parvispinus* can transmit viruses. Information about possible transmission of viruses by thrips other than TSMV has not been reconfirmed (Lewis 1973). The combined effects of thrips and thrips - transmitted viruses have to be examined at locations where these viruses occur.

Research methodologies. Thrips are difficult to observe in the field. This is the main reason why monitoring methodologies have to be developed based on studies concerning thrips behavior and life cycle. Additional information about feeding behavior, longevity, reproduction, pupation, etc. would be helpful to improve observation methods. Observations must relate to the real thrips population situation. The thrips monitoring methodologies, mentioned in this paper do not yet describe thrips population dynamics satisfactorily.

Thrips control. In Indonesia application of pesticides is the main method of thrips control used by farmers. Farmers generally associate leaf curling with a disease rather than with a sucking pest. They cannot distinguish between symptoms caused by thrips, aphids, mites or viruses. It is therefore difficult for farmers to choose appropriate pesticides. Field guides with descriptions of symptoms are therefore needed, next to continued insecticide screening in the laboratory, complemented with chemical control experiments both in screenhouse and field. Because of the assumed buildup of resistance by thrips, recommendations of insecticides have to be reconsidered carefully.

Since thrips mainly feed at night, spraying after sunset is recommended. In case of nonsystemic pesticides, experimentation with timing of insecticide applications is appropriate. In the Philippines, farmers were advised to spray with carbofuran simultaneously over a large area during a cool period at night (Van Balen, East-West Seed Company, Philippines, pers. comm. 1988).

Collaboration between AVRDC and national research institutes in Asia would contribute to accelerated research on biological control and screening for resistance. Basic research on natural enemies of thrips should be concentrated at AVRDC headquarters. This research should be initiated by introduction of thrips predators from other countries. For resistance screening, AVRDC should develop standard methodologies. National Asian research institutes can then exchange useful sources of resistance.

The research on plastic mulches must be continued. Plastic mulches have already been tested at many locations (e.g. MARDI Malaysia and AVRDC Taiwan). Some hot pepper farmers in the Magelang area, Central Java, already apply plastic mulch as a weed control measure. In order to optimize the use of plastic mulches, further experimentation is necessary to investigate the mechanisms of thrips control by plastic mulches.

The controlling effect of screen-covered nurseries has to be reconfirmed by continued experimentation. The third cultural practice that can affect thrips population growth is the reduction of fertilizer input. Research on the effects of fertilizers on thrips should be initiated.

The above cultural control measures delay the buildup of thrips populations. Through cultural control, the input of insecticides is reduced. Because of the harmful effects of pesticides on the environment in general, and on the natural or introduced predator fauna, an integrated crop management approach, including cultural and biological control, is recommended.

References

Ahamed, K., Mohamed, M. G., and Murthy, N.S.R. 1987. Yield losses due to various pests in hot peppers. Capsicum Newsletter, 6, 83-84.

Ananthakrishnan, T. N. 1980. Thrips. In: Harris, K. F., and Manmarosch, K. (ed.) Vectors of Plant Pathogens. Academic Press: 149-164.

Central Bureau of Statistics, Jakarta. 1988. Agricultural survey: Production of vegetables in Java 1988. Food Crops Statistics Division. 109 p.

Guyot, J. 1988. Revue bibliographique et premieres observations en Guadaloupe sur *Thrips palmi* Karny. Agronomie, 8(7), 565-575.

Jacot-Guillarmod, C. F. 1975. Thysanoptera catalogue. Annals of the Cage Provincial Museums (Nat. Hist.), 7(4),108.

Kalshoven, L.G.E. 1950. De plagen van de cultuurgewassen in Indonesie. Deel. I. N.V. uitgeverij W. van Hoeve, Den Haag/Bandung. 512 p.

Lewis, T. 1973. Thrips. Their biology, ecology and economic importance. Academic Press, London and New York, 349 p.

Lippold, P. C., Hongtrakula, T., Thongdeeta, S., Banziger, H., Hillerup, P. E., Kelderman, W., Supharngkasen, P. , and Deema, P. 1975. Use of colored sticky board traps in insect surveys. Plant Protection Service Technical Bulletin, Thailand, 29, 60 p.

Mantel, W. P., and van de Vrie, M. 1988. De Californische thrips, *Frankliniella occidentalis*, een nieuwe schadelijke tripssoort in de tuinbouw onder glas in Nederland. Ent. Ber. Amsterdam, 48(9), 140-144.

Ramakers, P. M. J. 1978. Possibilities for biological control of *Thrips tabaci* Lind. (Thysanoptera: Thripidae) in glasshouses. Med. Faculteit Landbouwwetenschappen Rijksuniversiteit Gent, 43(2), 463-469.

Sanap, M. M., Nawale, R. N., and Ajri, D. S. 1985. Seasonal incidence of chilli thrip and mite. Journal Maharashtra Agricultural University, 10(3), 345-346.

Singh, J. H., and Cheema, D. S. 1989. Present status of tomato and pepper production in India. In: Tomato and Pepper Production in the Tropics, AVRDC, Shanhua, Tainan, 452-471.

Stallen, M. P. K., and Arifin, A. T. 1990. Tentative observations on spray deposition on hot pepper plants. Internal communication LEHRI/ATA-395, 22, 30-33.

Sureshkumar, N., and Ananthakrishnan, T. N. 1987. Biotic interactions in relation to prey-predator relationship with special reference to some thrips species (Thysanoptera: Insecta). Journal Entomological Research, 11(2), 192-202.

Discussion

Y. **Hirose:** We made surveys of thrips fauna on fruit vegetables in Malaysia, Thailand and the Philippines, in 1987-88. But we didn't find *T. parvispinus* on any fruit or vegetables including peppers. Is the distribution of *T. parvispinus* restricted to Indonesia? Can this thrips be discriminated from *T. palmi* easily?

J.G.M. Vos: The thrips samples have been identified by a thrips taxonomist in The Netherlands. In addition to hot pepper, *T. parvispinus* has also been identified on potato in Indonesia (identified at CAB International Institute of Entomology in the UK). *Thrips parvispinus* is also reported during this workshop to occur in Malaysia on papaya and in Thailand on hot pepper.

N.T. Chang: Do you think it a better time to spray chemical when thrips appear in open flowers in the morning?

J.G.M. Vos: In case nonsystemic insecticides are used, it could be suggested to spray late in the afternoon or after sunset, since thrips feed on the underside of leaves during the night. Appropriate spray techniques have to be applied in order to achieve a good pesticide coverage of the undersides of leaves. In case systemic insecticides are used timing of application is not very relevant.

K. Bansiddhi: What did you do when mites occur while you want to study or control only thrips? How can you eliminate mites? What is the height of trap hanging above the crop canopy?

J.G.M. Vos: When mites are interfering in field trials in which thrips damage has to be observed, acaricides such as Kelthane or Omite are applied. Experimenting showed that a position just above crop canopy is best to trap the largest numbers of thrips.

Fauziah Hj Ismail: What is the recommended rate for fertilizer usage on chilis in order to reduce thrips infection?

J.G.M. Vos: In the Brebes area farmers apply up to 1000 kg N/ha. The recommended amount of N for hot pepper is 180-200 kg/ha. A trial is planned to assess the expected thrips reduction by appropriate nitrogen fertilizer application.

Research on Thrips in Malaysia

I. Fauziah* and H.A. Saharan**
***MARDI Research Station Jalan Kebun**
P.O. Box 186 GPO
41720 Klang, Selangor DE, Malaysia

****MARDI, P.O. Box 12301 GPO**
50774 Kuala Lumpur, Malaysia

Abstract

The current status of thrips on vegetables and other crops is reviewed. The common species of thrips emphasized included *Thrips palmi* Karny on cucumber, chili, brinjal and tomato; *Megalurothrips usitatus* Bagnall on yard-long bean, okra and french bean; *Thrips hawaiiensis* Morgan on okra, and bitter gourd. *Thrips parvispinus* Karny is a new pest problem on papaya, and its infestation helps in the invasion of the fungus *Cladosporium oxysporum*. Other species of thrips emphasized are *Anaphothrips corbetti* on orchids and *Frankliniella occidentalis* on chrysanthemums, roses and carnations. Thrips is an important vector of viruses on chili in Malaysia and it is the only vector reported to transmit tomato spotted wilt virus (TSWV). So far, no attempt has been made to identify the species of the thrips involved. Application of chemicals is the only available way of controlling thrips on vegetables as well as the other crops grown in Malaysia.

Background

Vegetable cultivation is a risky venture. It is beset with many problems and constraints including the pests and diseases. One of the pests which is becoming important in vegetable cultivation is thrips, which can be a major limiting factor to successful vegetable and other crop cultivation. There is a lack of published information on thrips and their management, especially on vegetables, because thrips have not been thoroughly studied in Malaysia. Control recommendations are largely based on experience. In fruit, such as papaya, Vijayasegaran (1986) observed that the crop was quite free of thrips at that time, but this pest has now become a serious threat to papaya cultivation in parts of the country. The same phenomenon is expected for vegetables and flowers, though no reports have yet been made. Thrips have been observed spreading to other crops from time to time.

This paper reviews the status of thrips in Malaysia, highlights some of the research findings and discusses possibilities of research collaboration.

Biology of Thrips

Thrips belong to the order Thysanoptera and about 4000 species exist in the world (Fenemore 1984). Some species of this order, such as those of the family Thripidae (Ross et al. 1982) are especially destructive. Thrips possess very short piercing mouthparts (Lewis 1973; Fenemore 1984) compared to Hemiptera, and can pierce only superficial cells of the plant surface which eventually coalesce giving a bleached appearance. In addition, there is often distortion of growth in response to the insect's injected saliva (Fenemore 1984). These small insects can cause severe damage to crops by destroying buds or blossoms, whitening or curling foliage, and deforming or scarring fruits.

Both adult males and females, together with the first and second nymphal instars, often exist simultaneously on flowers, but not prepupal or pupal stages (Vijayasegaran 1986). The adults of both sexes possess wings and fly readily and are also visible to the naked eye. Both nymphal stage I and II, however, are wingless, pale white to transparent and barely visible to the naked eye.

Parthenogenetic reproduction is common among thrips and males are rare in some species because the final nymphal instar of thrips is virtually a pupa. Thrips provide a link between insects with incomplete metamorphosis and those that display complete metamorphosis (Fenemore 1984).

Review of the Status of Thrips on Vegetables and Other Crops

At least five scientists are currently working on thrips in Malaysia, as follows:

Institution	Researcher	Crop	Area of Research
MARDI	Fauziah Ismail	Chili and other vegetables	Entomology/Monitoring and management of thrips
	Mohamad Roff Mohd Noor	Chili	Virology/Monitoring and management of virus diseases
	S. Vijayasegaran	Fruit	Entomology/chemical control
	Tan Chai Lin	Vegetables and fruits	Taxonomy
National University Malaysia (UKM)	Maryati Mohammad	Vegetables and other crops	Taxonomy

Vegetables

We are not aware of any published reports on thrips of vegetables in Malaysia. However, a survey done by a group of MARDI taxonomists in the farmers' fields at Sekinchan and Jalan Kebun (Selangor), Bertam (Penang) and Kuala Rompin (Negeri Sembilan) showed that there were three common species of thrips present on vegetables. They also observed that more than 70% of tomato, chili, brinjal and cucumber were infected by *T. palmi* (Tan Chai Lin, pers. Comm.).

The common species of thrips found on vegetables are:

Thrips palmi Karny on chili (*Capsicum annuum*); cucumber (*Cucumis sativus*); brinjal (*Solanum melongena*); tomato (*Lycopersicon esculentum*).

Megalurothrips usitatus Bagnall on yard-long bean (*Vigna sinensis*); french bean (*Phaseolus vulgaris*); okra (*Abelmoschus esculentus*).

Thrips hawaiiensis Morgan on okra (*A. esculentus*), and bitter gourd (*Momordica charantia*).

Chili

Chili is one of the important vegetables grown in the country and about 1500 ha of land are planted with chili (Saharan 1988). Thrips have caused serious problems in chili cultivation.

Both brownish nymphs and adult thrips occur commonly in flowers of chili plants. They may be found on flowers around the bases of the stamens or pistils (Fauziah 1984) or on the underside of young leaves. Heavy attacks of this pest may lead to complete drying, leaf dropping, plant stunting or death.

Thrips on chili can be reduced by using insecticides. Ooi (1990) reported that *T. palmi* can be controlled by applying furathiocarb (Deltanet) at 15-20 ml/10 l and diafenthiuron (Polo) at 8 ml/10 l. The chemicals were applied at weekly intervals and 11 sprays were required throughout the duration of the crop.

A virus disease, TSWV, which is transmitted by thrips (Mohamad Roff et al. 1989, 1990) is also affecting production of chili. The symptoms were: top necrosis, necrotic spots on leaves and necrotic streaks on stems (Mohamad Roff et al. 1989). At present, effective chemical control of viruses is impossible (Mohamad Roff et al. 1989). The disease incidence can be reduced by spraying with effective insecticides together with the use of barrier plants, reflective mulches and resistant varieties.

Fruits

Papaya

Thrips parvispinus Karny has been recognized as a new pest problem on papaya (*Carica papaya*) in Malaysia (Vijayasegaran 1986). The thrips feed on tender shoot primordia and cause damage to newly developing leaves. Severely affected plants were stunted and unable to bear fruits. Most papaya varieties are susceptible to thrips attack. As a result of *T. parvispinus* attack on young leaves, infection of saprophytis fungus *Cladosporium oxysporum* was usually observed (Lim 1989). The damaged leaf exhibited typical malformation symptoms, characterized by shattered and distorted leaf spots/streaks and shot-holes on the lamina.

Chemical control seems to be one of the most practical ways of controlling *T. parvispinus* (Vijayasegaran 1986; Lim 1989). The insecticides were applied either by cover spraying or by granular application. Two insecticides that provided good control of the thrips were Lambda-cyhalothrin (karate) and carbosulfan (Marshal). They were applied as cover sprays to fruiting papaya trees that were badly affected by thrips.

Flowers

Orchids

A common species of thrips on orchids is *Anaphothrips corbetti*. The species is particularly a problem during warm, dry months (Khoo and Ooi 1989). Both adults and nymphs have similar feeding habits and cause damage to flowers and leaves. When thrips are abundant, flower buds turn yellow and black; flowers may be malformed. Lim and Lim (1989) reported that the presence of thrips in the flower bud was suspected to cause 'black nose', a disease that leads to early fading of flowers and premature withering. If control is necessary, it can be done by spraying methiocarb or bendiocarb. However, frequent application of insecticides against thrips should not be practiced as this insect has a tendency to develop resistance rapidly (Lim and Lim 1989).

Ornamentals

Temperate cut flowers in Malaysia are mainly produced in the Cameron Highlands. The main cut flowers species grown are chrysanthemums, *Chrysanthemum morifolium*; roses, *Rosa* sp.; and carnations, *Dianthus caryophyllus*. These crops are grown under rain shelter structures. Thrips is one of the main pests during dry months of the year (January- March and June-August) (Safruddin et al. 1989). *Frankliniella occidentalis* is the major thrips species. Severely infested plants were stunted and the blooms were discolored. In 1988, thrips was found to be a major problem on chrysanthemums, where losses of up to 80% were recorded on some farms.

Safruddin et al. (1989) showed that application of some insecticides could reduce significantly the population of thrips on chrysanthemums. These chemicals included prothiophos, carbofuran, sulfur, tetradifon, prothiophos+petroleum oil and profenofos. These chemicals were applied at 10-day intervals.

Rice

A common species of thrips on rice is *Stenchaetothrips biformis* which attacks young rice seedlings at the early establishment stage. In direct-seeded fields where land preparation is poor or water supply is a problem, this pest can spread rapidly (Ali et al. 1990).

The pest can be controlled easily by applying insecticides e.g. carbaryl, but cultural practices such as good land preparation and water management are important to avoid the infestation. Although thrips do not cause any apparent yield loss, application of chemicals increases the cost of production.

Future Research Collaboration

To date, Malaysia has no collaborating research on management of thrips, especially on vegetables. Any collaborative efforts in research are going to be beneficial since resources and expertise can be shared. In Malaysia, research on management of thrips on vegetables is emphasized in the following areas:

(1) Survey on the status of thrips on vegetables throughout the country.
(2) Identification and characterization of thrips species.
(3) Ecological studies of thrips.
(4) Studies on virus-vector relationship(s).
(5) Development and implementation of an integrated pest management control program on thrips.

International/regional institutions could contribute in the following ways:

(1) Circulate research information.
(2) Conduct training and regional workshops.
(3) Establish monitoring techniques for thrips.
(4) Search for potential biological agents on thrips.
(5) Provide identification services.

Conclusion

Various thrips species attack vegetables and others crops in Malaysia, but these pests have not been thoroughly investigated. It is therefore felt that a proper research program on thrips is needed, with collaboration between Malaysian researchers and those from various international organizations.

Acknowledgments

The authors wish to thank Mr. H.J. Lim, Dr. W.H. Lim, Mr. C.L. Tan, Mr. A.M. Abd. Aziz, Dr. S.A.R. Syed Abd. Rahman, and Mr. M.N. Mohamad Roff of MARDI, and Dr. Maryati Mohamad of UKM, for their invaluable assistance in the preparation of this paper.

References

Ali, H., Chang, P.M., Saad, A., and Nik Mohd Noor, N.S. 1990. Potential pests in direct seeded rice in Peninsular Malaysia. Paper presented in The Rice Conference on Direct-Seeding Technology, MARDI and MACA, 25-27 September 1990. Penang, Malaysia. 4 p.

Fauziah, I. 1984. Screening of insecticides to control insect pests on chili (MARDI internal mimeo. report).

Fenemore, P. G. 1984. Plant Pests and Their Control. Revised Edition. London: Butterworth. 280 p.

Khoo, K.C., and Ooi, P.A.C. 1989. Orchid pests and their management. Proceedings MAPPS-MARDI, Seminar on Pests and Diseases of Ornamentals, 30 September-1 October, Cameron Highlands, Pahang, 101-105.

Lewis, T. 1973. Thrips: Their Biology, Ecology and Economic Importance. London and New York: Academic Press, 349 p.

Lim, W.H. 1989. Bunchy and malformed tops of papaya cv. Eksotika caused by *Thrips parvispinus* and *Cladosporium oxysporum*. MARDI Res. J., 17(2), 200-207.

Lim, W.H., and Lim, T.K. 1989. Current status of orchid diseases in Malaysia. Proceedings MAPPS-MARDI, Seminar on Pests and Diseases of Ornamentals, 30 September-1 October, Cameron Highlands, Pahang, 75-82.

Mohamad Roff, M.N., Saharan, H.A., and Ong, C.A. 1989. Research on chili viruses in Malaysia. Paper presented at the AVRDC Planning Meeting for Germplasm Improvement Sub-network of ADB Project, 31 May-02 June 1989, AVRDC, Taiwan. 13 p.

1990. Research on virus diseases on vegetables in Malaysia. Paper presented at the Regional Consultation and Training on Vegetable Viruses, 1-28 October 1990, AVRDC, Taiwan, ROC. 16 p.

Ooi, G.T. 1990. Report on the bio-efficacy of Deltanet[R] 200 EC against *Thrips palmi* and *Aphid* spp. in chilli. MARDI Jalan Kebun (mimeo.) Report.

Ross, H.H., Ross, C.A., and Ross, J.R.P. 1982. A Textbook of Entomology. Fourth Edition. Canada: John Wiley & Sons, Inc. 666 p.

Safruddin, H., Syed Abdul Rahman, S.A.R., and Bakli, T.M. 1989. Chemical control of thrips and mites on highlands ornamentals. Paper presented in Seminar on Pests and Diseases of Ornamentals, 30 September-1 October. Cameron Highlands, Pahang, 11.

Saharan, H.A. 1988. Research on vegetables in Malaysia. Proceedings Vegetable Research in Southeast Asia. AVRDC-ADB Workshop on Collaborating Vegetable Research in Southeast Asia, 1?-16 August 1988, AVRDC, 65-72.

Vijayasegaran, S. 1986. *Thrips parvispinus* Karny (Thripidae: Thysanoptera) - A potential new pest of papaya. Proceedings of 2nd International Conference on Plant Protection in The Tropics, 17-20 March 1986, Genting Highlands. 140-142.

Discussion

N.T. Chang: Does *T. hawaiiensis* occur on banana? Tobacco ringspot virus also can be transmitted by *T. tabaci*.

I. Fauziah: So far we have no report of *T. hawaiiensis* occurring on banana. Thank you for the information.

S. Sastrosiswojo: What are the priority crops to be tackled in your institute? What thrip species is supposed to be the major pest of the priority crops?

I. Fauziah: The priority crops are chili and tomato. We have no results yet on the species of thrips involved.

Thrips of Vegetables and Other Commercially Important Crops in Thailand

K. Bansiddhi and S. Poonchaisri
Entomology and Zoology Division
Department of Agriculture
Ministry of Agriculture and Cooperatives
Bangkok 10900, Thailand

Abstract

Thrips are abundant in vegetation, especially in flowers. They damage plants in many ways, such as producing galls, rolling up leaves and living inside. Some feed primarily on the sap of living plant cells. If the cell contents of a leaf surface is fed on extensively, silvery patches are formed by the presence of air. These patches gradually become brown and finally the leaf may fall off. Some thrips act as vectors of plant diseases. Thrips are one of the most important pests of economically important plants in Thailand. Many crops, including vegetables, are damaged by thrips which results in economic loss. Many species of thrips are found in Southeast Asia, but the list of thrips in Thailand is still relatively short. Much of the information on them deals with their ecology and control.

Introduction

Thrips are important agricultural pests not only because of the mechanical injuries caused by their feeding, but for being vectors of bacterial, fungal and viral diseases. Among the pests of vegetables, thrips is considered to be the most destructive sucking insect in both the highland and lowland areas. Other sucking insect pests such as aphids and jassids are considered minor pests. The crops most seriously attacked by thrips are chilis, watermelon, cucumber, onion, shallot, garlic, eggplant, tomato, potato, asparagus, yard-long bean, garden pea, okra and mushroom.

In general, the thrips damage to leafy or fruit vegetables results in decrease of prices due to the inferior quality at harvest. Thrips infestations can also lower the vigor of the plant and delay the time of harvesting, thereby causing marketing problems and difficulties in planning subsequent crops, with a subsequent loss of income (Jones and Jones 1973). In Thailand the leafy vegetables (crucifers) are generally less damaged than fruit vegetables (watermelon, chili, eggplant, tomato and okra). Chili thrips, watermelon thrips and eggplant thrips are troublesome in dry seasons, and in the drier parts such as the northeast and west, the important growing areas for chili, watermelon, eggplant and onion. Fruit vegetables are normally attacked in dry years or in periods of dry weather. The young leaf buds or flowers may be attacked by the nymphs, and the tiny punctures give the leaves a silvery white appearance so that they shine in the sun. They also cause the fruits to develop silvery patches which become brown scars, and also cause twisting and curling of the leaves, which fail to develop or fall off.

The identification of thrips in this paper is based on Palmer et al. (1989) and Ananthakrishnan (1971).

Thrips Pests of Vegetables

The important thrips species in Thailand are *Scirtothrips dorsalis*, *Thrips parvispinus*, *Thrips tabaci*, *Haplothrips floricola*, and *Thrips flavus*.

The following important crop species are attacked by at least one of the above thrips species:

Chili	*Capsicum annuum*
Watermelon	*Citrullus lanatus*
Cucumber	*Cucumis* spp.
Onion	*Allium cepa*
Shallot	*Allium ascalonicum*
Garlic	*Allium sativum*
Eggplant	*Solanum melongena*
Tomato	*Lycopersicon esculentum*
Potato	*Solanum tuberosum*
Asparagus	*Asparagus officinalis*
Yard-long bean	*Vigna sinensis* var. *sesquipedelis*
Garden pea	*Pisum sativum*
Okra	*Abelmoschus esculentus*
Orchid	*Vanda* spp.
Rose	*Rosa* spp.
Chrysanthemum	*Chrysanthemum hortorum*
Jasmine	*Jasminum sambac*
Gerbera	*Gerbera jamesonii*
Rice	*Oryza sativa*
Corn	*Zea mays*
Sugarcane	*Saccharum officinarum*
Cotton	*Gossypium herbaceum*
Mulberry	*Morus alba*
Soybean	*Glycine max*
Groundnut	*Arachis hypogaea*
Rambutan	*Naphelum lappaceum*
Mangosteen	*Garcinia mangostana*
Mango	*Mangifera indica*
Papaya	*Carica papaya*
Grape	*Vitis vinifera*

Research activities

The few research activities on thrips in Thailand deal mainly with control methods. This paper covers the research results on vegetables and some other economically important crops.

Scirtothrips dorsalis is troublesome to chili in the dry season from November to April and in the drier areas (northeast and west), the important chili-growing areas. Chili and sweet pepper suffer damage by the nymphs, partly on the leaves, buds or flowers which fail to develop or are abnormally shaped, but flowers and young fruits are more commonly damaged. The fruits produced are misshapen and have markings on the surface with a silvery sheen resulting from the empty epidermal cells filled with air.

Bansiddhi et al. (1983) carried out insecticide efficacy experiments on farmer's fields at Kanchanaburi Province during May to November 1985. *S. dorsalis* and *T. parvispinus* could be controlled by spraying with carbosulfan at 0.31 kg a.i./ha, phosalone at 0.87 kg a.i./ha and mexacarbate at 0.75 kg a.i./ha. He suggested that spraying should be done under dry conditions since the rainy season or wet weather may decrease or delay an infestation.

Bansiddhi et al. (1983) reported on the comparison between electrodynamic and conventional sprayers to control *S. dorsalis* and *T. parvispinus* on farmers' fields in Kanchanaburi Province (important chili-growing area). The results showed that the electrodynamic sprayer gave better control than the conventional sprayer.

Thrips tabaci is similar to *S. dorsalis* and *T. parvispinus* and causes damage in the dry season. In dry weather, the young leaves of onions or shallots may be attacked by the nymphs; the tiny punctures cause the leaves to assume a silvery white appearance so that they shine in the sun. It also causes twisting and curling of leaves when heavily infested. A good shower of rain stops the attack and the damaged leaves grow normally. Control can be obtained by weekly spraying with imidacloprid at 0.25 kg a.i./ha and promecarb at 0.3 kg a.i./ha.

Keinmeesuke (1987) conducted one insecticide trial to control thrips on asparagus during 1987 on farmers' fields in Petchaburi Province. The results showed that carbosulfan at the rate of 0.3 kg a.i./ ha, methiocarb at 0.46 kg a.i./ha, and formetanate hydrochloride at 0.39 kg a.i./ha gave good control of *Thrips tabaci.*

Since 1975, *Haplothrips floricola* has greatly reduced the fruit setting period of watermelon (including cucumbers). On early planted crops, only a few fruits are usually produced because of thrips. Entomologists from the Entomology and Zoology Division, Department of Agriculture, Ministry of Agriculture and Cooperatives, found that the effective chemicals to control this species of thrips were carbofuran, carbosulfan, methiocarb, formethanate and methomyl.

Eggplant thrips, *Thrips flavus* and *Haplothrips floricola*, cause damage to both fruits and leaves, but damage on fruits is of practical economic importance. The high quality requirements and extensive cultivation of eggplant and tomato implies that *Thrips flavus* or *Haplothrips floricola* are economically very important pests.

In 1980, Chouvalitwongporn reported that chrysanthemum flowers were infested by *Microcephalothrips abdominalis* Crawford and *Thrips florum* Schmutz. The infestation occurred as soon as the flowers were formed, and the population of thrips increased as the flowers grew larger. The nymphal population peaked at the blooming stage but adult populations gradually increased and were highest as the flowers faded.

Yellow sticky board traps at a height of 14 cm above the chrysanthemum plants was the most effective in catching the adult thrips. Flight activity of adults was high from 0800 to 1200. Spatial patterns of thrips attacking chrysanthemum flowers was aggregated distribution. Neither the fluctuation of population of thrips in flowers nor the movement from sticky traps were correlated with the mean temperature or the total annual rainfall.

In 1985, Chouvalitwongporn reported that the most effective insecticides for controlling thrips attacking chrysanthemum flowers was carbosulfan at the rate of 0.312 kg a.i./ha. The other insecticides which gave good control were prothiophos at 0.18 kg a.i./ha, benfuracarb at 0.312 kg a.i./ha and formetanate at the rate of 0.31 kg a.i./ha. When flowering begins, five sprayings should be done at 4-day intervals, and at 3-day intervals thereafter.

Control measures recommended practices

Chemical control of thrips is widely practiced by the farmer. The farmers generally apply the insecticides routinely, both as a preventive and curative measure. The growers also apply the insecticides at higher rates and frequencies under adverse weather conditions. During the rainy season or wet weather periods, dosages are doubled or tripled with applications done every 2-3 days. These practices have led to severe problems.

The common insecticides used for controlling thrips in vegetable production are more numerous especially in watermelon, asparagus and chili (Table 1). These include carbaryl, prothiophos, methiocarb, carbosulfan, phosalone, methomyl, formetanate, monocrotophos, triazophos, methamidophos, azinphos-ethyl, cypermethrin and cyhalothrin-L. Farmers generally prefer cocktail formulations (mixing 2-5 kinds of chemicals together), and make seasonal changes in insecticides because of the development of insecticide tolerance (resistance) in the thrips population.

In general, other control measures, such as cultural and mechanical, are occasionally applied but rarely found effective in vegetable-growing areas. However, the mechanical method, especially the yellow sticky trap, has been tried in Thailand since 1984, but the results have not been confirmed. These control methods may be effective in reducing the density of thrips, but it is difficult to achieve adequate control using only one method. Therefore, integrated pest control is urgently needed.

Table 1. Thrips of economically important crops in Thailand and insecticides recommended for their control.

Scientific name	Crop species attacked	Recommended Insecticides	Rate (kg a.i./ha)
Scirtothrips dorsalis, Thrips parvispinus	Chili	carbaryl (Sevin)	0.53-0.79
		prothiophos (Tokuthion)	0.31-0.46
		methiocarb (Mesurol)	0.31-0.46
		carbosulfan (Posse)	0.12-0.18
		phosalone (Zolone)	0.87
Thrips flavus	Eggplant and tomato	carbosulfan (Posse)	0.31
		prothiophos (Tokuthion)	0.46
		methomyl (Lannate)	0.33
Thrips tabaci	Shallot, onion, garlic	The same as in chili	
Haplothrips floricola	Cucumber and	carbofuran (Furadan)	2.15
Thrips tabaci	Watermelon	carbosulfan (Posse)	0.31
		methiocarb (Mesurol)	0.46
		formetanate (Dicarzol)	0.46
		methomyl (Lannate)	0.28-0.33
Thrips tabaci	Asparagus	carbosulfan (Posse)	0.25-0.31
		methiocarb (Mesurol)	0.46
Frankliniella spp.	Groundnut	monocrotophos (Azodrin)	0.65
Caliothrips indicus		monocrotophos (Nuvacron)	0.68
Megalurothrips sp.		methiocarb (Mesurol)	0.46
Scirtothrips dorsalis			
Haplothrips sp.	Rambutan	cyhalothrin L. (Karate)	0.007
Thrips hawaiiensis			
Scirtothrips dorsalis		monocrotophos (Azodrin)	0.56
Megalurothrips sp.		formetanate (Dicarzol)	0.23
Thrips	Mangosteen	carbosulfan (Posse)	0.31

(Continued)

Scientific name	Crop species attacked	Recommended Insecticides	Rate (kg a.i./ha)
Scirtothrips dorsalis	Mango	monocrotophos (Azodrin)	0.65
		carbaryl (Sevin)	0.53-0.79
		cyhalothrin L. (Karate)	0.007
		fenpropathrin (Danital)	0.030
		monocrotophos + cypermethrin (Azcord)	0.15
		formetanate (Dicazol)	0.46
Thrips coloratus	Grape	monocrotophos (Azodrin)	0.37
Thrips hawaiiensis		formetanate (Dicarzol)	0.23
Selenothrips rubrocinctus		methiocarb (Mesurol)	0.46
Haplothrips spp.		carbosulfan (Posse)	0.18
Aeolothrips sp.			
Megalurothrips sp.			
Thrips palmi	Orchid	carbosulfan (Posse)	0.18-0.31
Dichromothrips corbetti		prothiophos (Tokuthion)	0.31-0.46
Thrips florum	Chrysanthemum	carbosulfan (Posse)	0.18
Microcephalothrips abdominalis		prothiophos (Tokuthion)	0.46
Thrips apicatus		benfuracarb (Oncol)	0.31
Thrips sp.	Jasmine	carbosulfan (Posse)	0.18-0.31
Microcephalothrips abdominalis	Dahlia	prothiophos (Tokuthion)	0.46
		benfuracarb (Oncol)	0.31
Stenchaetothrips biformin	Rice	malathion (Malathion)	0.51
		carbaryl (Sevin)	0.53
Frankliniella williamsi	Corn	tetrachlorvinphos (Gardona)	0.23
		azinphos-ethyl (Gusathion)	0.31
		mevinphos (Phosdrin)	0.12
Thrips palmi	Cotton	butocarboxim (Drawin)	1.25
Pseudodendrothrips ornatissimus	Mulberry	monocrotophos (Azodrin)	0.31
Pseudodendrothrips sp.		phosalon (Zolone)	0.62
		triazophos (Hostathion)	0.9
Megalurothrips usitatus	Mungbean	methamidophos (Tamaron)	0.46-0.62
		methamidophos (Monitor)	0.46-0.62
		omethoate (Folimat)	0.62-0.78
		omethoate (Folimat)	0.62-0.87
		monocrotophos (Azodrin)	0.75-0.93
		monocrotophos (Nuvacron)	0.75-0.87
		triazophos (Hostathion)	0.62-0.75
		prothiophos (Tokuthion)	0.78-0.93
		formetanate (Rinate)	0.31-0.39
		dialifor (Torak)	0.44-0.58
		methiocarb (Mesurol)	0.46-0.62
		methomyl (Lannate)	0.34-0.42

References

Ananthakrishnan, T.N. 1971. Thrips (Thysanoptera) in agriculture, horticulture & forestry diagnosis, bionomics & control. J. Sci. Industrial Res., 30(3),113-146.

Bansiddhi, K., Vitayarak, W., Velchakit, D., and Vatanatanyagum, A. 1983. Field comparison on an efficiency between electrodynamic and conventional sprayer for controlling chili pests. Annual Report of Entomology and Zoology. Dept. of Agri., Bangkok, Thailand. (in Thai) 17 p.

Bansiddhi, K., Vitayarak, W., Onboon, P., and Vatanatanyagum, A. 1985. Test on the efficacy of certain chemicals for controlling chili pests. Annual Report of Entomology and Zoology. Dept. of Agri., Bangkok, Thailand (in Thai). 13 p.

Chouvolitwongporn, P. 1980. Bionomic studies of *Microcephalothrips abdominalis* Crawford and *Thrips florum* Schmutz on chrysanthemum. M.Sc. Thesis of Kasetsart University, Bangkok, Thailand (in Thai) 72 p.

1985. Study on the efficacy of certain insecticides for controlling chrysanthemum thrips, *M. abdominalis* Crawford and *T. florum* Schmutz. Annual Report of Entomology and Zoology, Dept. of Agri., Bangkok, Thailand. (in Thai) 10 p.

Jones, F.G.W., and Jones, M.G. 1973. Insects of minor economic importance. Pest of Field Crops, 39-43.

Keinmeesuke, P. 1987. Insecticides trial for controlling thrips on asparagus. Annual Report of Entomology and Zoology. Dept. of Agri. Bangkok, Thailand (in Thai) 8 p.

Palmer, J.M., Momd, L.A., and du Heaume, D.J. 1989. C.I.E. Guides to insects of importance to man. 2. Thysanoptera. ed. CR.

Discussion

S. Sastrosiswojo: Do you have any information that thrips also transmitted mycoplasm disease on vegetables?

K. Bansiddhi: No information available.

E.N. Bernardo: How can farmers differentiate readily thrips infestation from broad mite infestation on pepper? Does broad mite infestation result in death of the growing shoot tip?

K. Bansiddhi: Leaves curl and roll when the damage is caused by thrips, and leaves curl and roll down when damage is caused by broad mites. Only young shoots wilt or die after heavy infestation.

J.G.M. Vos: What is the reason for the thrips pest problem in vegetable production in Thailand?

K. Bansiddhi: It is not only in vegetable production; these pests are a problem in whatever crops farmers grow.

Important Thrips Species in Taiwan

Niann Tai Chang
Department of Plant Protection
National Pingtung Institute of Agriculture
Pingtung, Taiwan

Abstract

There were 99 species of thrips recorded in Taiwan in 1936. Recent studies indicate that there are 156 species, of which 70 can damage various crops in the field, including 11 that attack economically important crops. The increasing importance of phytophagous thrips has resulted in increased research interest in their bionomics and control. This report presents information on most of the studies conducted during 1975-90. The major food plants, damage, basic biology, population fluctuation, and control methods of seven important species are covered: *Frankliniella intonsa* Trybom, *Megalurothrips usitatus* (Bagnall), *Rhipiphorothrips cruentatus* Hood, *Scirtothrips dorsalis* Hood, *Thrips hawaiiensis* Morgan, *Thrips palmi* Karny, and *Thrips tabaci* Lindeman. A list is included of 27 species of thrips recorded on vegetable crops in Taiwan. Four thrips species that attack economically important crops are: *T. palmi* on Cucurbitaceae and Solanaceae; *F. intonsa* on Liliaceae; *T. tabaci* on Amaryllidae, and *M. usitatus* on Leguminosae. Twenty-eight insecticides are recommended to control thrips on various agricultural and horticultural crops. Other potential control strategies are also noted.

Introduction

The thrips in Taiwan were studied by Takahashi starting around 1920. After many years of observation, the thrips fauna was reported and 99 species of thrips listed (Takahashi 1936). Although as many as 6000 species have been recorded worldwide (Ananthakrishnan 1979), only 156 species have been found in Taiwan (Chen 1987). Ten of 22 economically important species of thrips listed by Chen (1984) were the same as those recorded by Takahashi (1935). However, only 11 species were recognized as the most important thrips in Taiwan by Chen (1987) (Table 1).

Little attention had been paid to thrips until 1970. In the past the cane thrips, *Thrips serratus* (=*Baliothrips serratus*), was a serious pest of sugarcane, and was studied in detail by Wang (1952). The importance of this thrips decreased following the decline of the sugar industry in Taiwan. Except for the study of onion thrips, *Thrips tabaci* by Fang (1960), few reports on thrips were published until recently. After 1970, some new species of thrips were identified by Chen (1976, 1977, 1979a, 1981, 1982). Focusing on corn, tea, leguminous plants, and mulberry, Chen (1978, 1979b, 1979c, 1980) listed 17, 10, 22 and 21 species of thrips, respectively, on those plants.

The rapid reproduction, high mobility, with polyphagous and interstitial characteristics have led thrips to become increasingly important over the years. The feeding or oviposition of thrips on leaves, flowers, fruits or even pods of various crops usually inflict significant damage in quantity and/or quality. The potential of thrips as a vector further enhances their importance. In this paper, the serious thrips pests, the major crops attacked, the control measures as well as the research activities on thrips in Taiwan are reviewed.

Table 1. List of economically important thrips in Taiwan.

	Takahashi (1935)	Chen (1984)	Chen (1987) Crop attacked
Rhipiphorothrips pulchellus Morgan	**M. abdominalis*	*#*M. abdominalis*	Chrysanthemum
Heliothrips haemorrhoidalis Bouche	*Frankliniella intonsa* (Trybom)	#*F. intonsa*	Cutflower, Beans, Asparagus
Chirothrips takahashii Moulton	**T. hawaiiensis*	*#*T. hawaiiensis*	Banana, Citrus, Tea, Beans
Anaphothrips flavicinctus Karny	**T. tabaci*	*#*T. tabaci*	Onion, Asparagus
Selenothrips rubrocinctus Giard	*Thrips palmi* Karny	#*T. palmi*	Watermelon, Eggplant
Frankliniella formosae Moulton	**Baliothrips serratus* (Kobus)	*#*B. serratus*	Sugarcane
Ayyaria chaetophora Karny	*Bathrips melanicornis* (Shumsher Singh)	#*S. biformis*	Rice
Taeniothrips lefrovi Bagnall	*Anaphothrips sudaensis* Trybom	#*A. sudaensis*	Corn
Taeniothrips varicornis Moulton	*Frankliniella williamsi* Hood	*#*S. dorsalis*	Mango, Lichee, Peanut
Taeniothrips distalis Karny	*Ceratothrips lefroyi* (Bagnall)	#*R. cruentatus*	Waxapple, Mango
Taeniothrips clarus Moulton	*Megalurothrips usitatus* (Bagnall)	*#*H. chinensis*	Weeds
Taeniothrips smithi Zimmermann	*Parabaliothrips takahashii* Priesner		
Taeniothrips sp.	*Pseudodendrothrips mori* (Niwa)		
Scirtothrips dorsalis Hood	**S. dorsalis*		
Thrips clarus Moulton	*Stenchaetothrips biformis* (Bagnall)		
Thrips tabaci Lind	*Stenchaetothrips dissidens* (Ananthakrishnan & Gadadish)		
Thrips oryzae Williams	**H. haemorrhoidalis*		
Thrips hawaiiensis Morgan	*Rhipiphorothrips cruentatus* Hood		
Microcephalothrips abdominalis	**S. rubrocinctus*		
Thrips serratus Kobus	**G. uzeli*		
Litotetothrips rotundus Moulton	**H. aculeatus*		
Liothrips floridensis Watson	**H. chinensis*		
Gynaikothrips uzeli Zimm			
Mesothrips claripennis Moulton			
Haplothrips aculeatus Fabr			
Haplothrips gowdeyi Frankl			
Haplothrips chinensis Priesner			
Haplothrips vernoniae Priesner			
Rhaebothrips lativentris Karny			

* Same as the list of Takahashi (1935).
# Same as the list of Chen (1984).

Important Thrips

Thrips tabaci

The onion thrips, *Thrips tabaci*, is a cosmopolitan pest of various agricultural crops. This polyphagous insect infests tobacco, tomato, onion, cotton, etc., and has been recorded worldwide (Ananthakrishnan 1984). They conspicuously damage the leaves and flowers of Amaryllidae plants (especially *Allium* spp.) in Taiwan (Table 2).

Table 2. List of crops damaged by *Thrips tabaci* Lindeman in Taiwan.

Crops	Infesting parts	Reference
Allium spp.	Leaf	Takahashi 1936
Leek (*Allium porrum*)	Leaf, Flower	Fang 1960
Corn (*Zea mays*)	?	Chen 1978
Green bean (*Vigna radiata*)	Leaf	Chen 1979c
Green asparagus (*Asparagus officinalis*)	Shoot, Leaf	Chen 1984
Cucurbits	?	Wang et al. 1987
Onion (*Allium cepa*)	Leaf, Flower	Lu and Lee 1985; Lu1990
Scallion (*Allium ascalonicum*)	Leaf, Flower	Lu and Lee 1985; Lu1990

On the leaves of *Allium* spp., *T. tabaci* rasp and feed on the surface tissues, which cause white spots on leaves and the whole plant may dry out eventually. Lu and Lee (1985) evaluated the relationship (after 1 week infestation) between the number of this thrips (X) and percentage of damaged leaves (Y) of green onion as $Y = 4.6998 + 1.1767 X$ in adults and $Y = 0.5690 + 0.5201 X$ in larvae.

No study, however, has reported damage to cabbage by *T. tabaci* as is common in the USA (Shelton and North 1986), nor is there evidence that they can transmit tobacco ringspot virus, tobacco streak virus, or tomato spotted wilt virus (TSWV) (Ananthakrishnan 1980) in Taiwan.

The development and reproduction of *T. tabaci* under different temperatures were studied by Lu and Lee (1987). It takes about 30 days to complete a generation when rearing this species under room temperature. The low temperature threshold for the development of eggs, larvae, and pupae of *T. tabaci* were 5.85, 5.89 and 8.80°C, respectively (Lu and Lee 1987). About 10 eggs are laid per female under laboratory conditions. The scarcity of males of *T. tabaci* was known in most parts of the world (Lewis 1973). Similarly, only females and parthenogenic reproduction of this thrips have been found in Taiwan to date (Chen 1978; Lu and Lee 1987).

Thrips tabaci prefers to inhabit the under side of the leaf (Lu and Lee 1987). On shallot (*Allium cepa* var. *aggregatum*), this species showed a higher distribution on the upper side (6 cm above the ground) at 1630 hours (Lu 1989). Their spatial distribution pattern in the garlic field was also determined as an aggregative type (Lu 1989).

Takahashi (1936) indicated *T. tabaci* are common in the field on the leaves and flowers of Amaryllidae crops from April to June near Taihoku. Fang (1960) also noted that the population peak of this thrips occurs at the same period on leeks around the central area of Taiwan, and there are 5-8 generations/year according to Fang. However Chang (1973) mentions severe damage occurring between September and April. Lu and Lee's (1987) data of a 3-year field survey in southern Taiwan indicated that the population density of *T. tabaci* increased from November to April, especially in

February and March; the low-temperature season. According to the abundance of *T. tabaci* at different times at different locations, the suitable temperature for the population increase of *T. tabaci* in the field is about 20-25°C.

On *Allium* spp. spraying of eight insecticides is recommended to control *T. tabaci* (Table 3). Two other granular insecticides (phorate and phosfolan) at a dosage of 1.0 kg a.i./ha in soil treatment before planting were found effective against this thrips (Chang 1973). The nonchemical control measures were also tried recently. In an onion field, the pale blue color was most attractive to *T. tabaci* among seven colors tested (Lu 1990). Silver mulches also proved effective in repelling onion thrips in the field, especially when shallots (*Allium ascalonicum*) were sparsely planted and during their seedling stage (Lu 1990).

Table 3. List of officially recommended insecticides for the control of thrips in Taiwan (from Taiwan Provincial Government, 1990).

Crops	Objective Thrips	Recommended Insecticides	Dosage	Dilution
Leek, Scallion	*Thrips tabaci*	50% Dichlorvos, EC		1:1500
Onion & Garlic		58% Naled, EC		1:1000
		50% Malathion, EC		1:1500
		25% Salithion, EC		1: 500
		25% Bromophos, EC		1: 500
		50% Phenthoate, EC		1:1000
		50% Cartap, SP		1:1000
		90% Methomyl, WP		1:3000
Watermelon	*Thrips palmi*	2.8% Cyhalothrin, EC	0.5-0.6 l/ha	1:2000
		48.34% Carbosulfan, EC	0.6-1.2 l/ha	1:1500
		85% Carbofuran, WP	0.5-0.6 kg/ha	1:2000
		50% Methiocarb, WP	1.0-1.7 kg/ha	1:1000
		2.8% Deltamethrin, EC	0.5-0.6 l/ha	1:2000
		40.64% Carbofuran, WP	1.2-1.5 l/ha	1: 800
		25% Carbosulfan, WP	1.5-2.0 kg/ha	1: 700
		50% Bendiocarb, WP	0.8 kg/ha	1:1500
		60% Vemidothion + MIPC+ BPMC	1.0 l/ha	1:1200
		25% Fluvalinate, EC	0.4 l/ha	1:3000
Asparagus	*Frankliniella intonsa*	50% Methamidophos, S	1.25 l/ha	1:1200
Eggplant	*Thrips palmi*	2.8% Deltamethrin, EC	1.0-1.5 l/ha	1:1000
		10% Permethrin, EC	1.0-1.5 l/ha	1:1000
		50% Formetante, SP	1.0-1.5 l/ha	1:1000
		40% Pyridaphenthion, EC	1.0-1.5 l/ha	1: 800
Peanuts	*Scirtothrips dorsalis*	50% Methamidophos, S	0.7 l/ha	1:1200
Citrus	*Scirtothrips dorsalis*	48.34% Carbosulfan, EC	1.0-2.0 l/ha	1:1000
Banana	*Thrips hawaiiensis*	2.8% Deltamethrin, EC	0.3 l/ha	1:3000
		48.34% Carbosulfan, EC	0.3 l/ha	1:1000
Mango	*Scirtothrips dorsalis*	48.34% Carbosulfan, EC	1.5-2.0 l/ha	1:1000
	Rhipiphorothrips cruentatus			
	Thrips hawaiiensis			
Waxapple	*Rhipiphorothrips cruentatus*	25% Fluvalinate, EC	0.1-0.25 l/ha	1:3000
		2.8% Cyhalothrin, EC	0.6-0.75 l/ha	1:2000
		2.8% Deltamethrin, EC	0.3-1.0 l/ha	1:1500
		3% Alphacypermethrin, EC	2.0-5.0 l/ha	1:1000
		48.34% Carbosulfan, EC	0.2-0.5 l/ha	1:1500
Rose	*Frankliniella intonsa*	50% Methamidophos, S		1:2000
	Thrips hawaiiensis	75% Carbofuran, WP		1:2000
		40.8% Chlorpyrifos, EC		1:1500
Chrysanthemum	*Microcephalothrips abdominalis*	5.3% Mevinphos, EC	0.8-1.0 l/ha	1:1000
		70% Phosphamidon + Mevinphos, EC	0.3-0.1 l/ha	1:2000

Scirtothrips dorsalis

The chili thrips, *Scirtothrips dorsalis* is distributed throughout the Eastern Hemisphere, including most countries of Asia, Australia and the Pacific islands. This is mainly a leaf-infesting species, although it has been recorded on various parts of vegetable and fruit plants in Taiwan (Table 4).

Table 4. List of crops damaged by *Scirtothrips dorsalis* Hood in Taiwan.

Crops	Infesting parts on plant	Reference
Corn (*Zea mays*)	?	Chen 1978
Leguminous plants	Leaf, Bud	Chen 1979c
Peanuts (*Arachis hypogaea*)	Leaf, Flower	Takahashi 1936; Tsai 1965; Chen, W. S. 1980; Chen 1984; Yen 1984
Tea (*Camellia sinensis*)	Leaf	Takahashi 1935, 1936; Chen 1979b, Chen 1984
Green asparagus (*Asparagus officinalis*)	Shoot, Stem, Flower	Tang 1975, 1976a
Green pepper, hot pepper (*Capsicum annuum*)	Bud, Young leaf	Su and Chen 1986
Citrus (*Citrus* spp.)	Fruit skin	Tsai 1984a
Grapevine (*Vitis vinifera*)	Leaf, Flower, Bud, Fruit	Tang 1973; Shih 1989
Indian jujube (*Zizyphus mauritiana*)	Bud	Wen 1988
Mango (*Mangifera indica*)	Shoot, Flower Leaf, Fruit skin	Takahashi 1936; Tsai 1965; Lee and wen 1982; Chen 1984; Lee 1984,1988
Passion fruit (*Passiflora edulis*)	Shoot, Leaf	Wen and Lee 1984
Strawberry (*Fragaria chiloensis*)	Leaf	Takahashi 1936; Tsai 1965; Chen 1984
Sugar apple (*Annona squamosa*)	Shoot, Flower	Shieh 1988, Shieh and Sheen 1988

This thrips was noted as the most important or dominant pest species on sugar apple, passion fruit, and grapevine (Shieh 1988; Wen and Lee 1984; Shih 1989). *Scirtothrips dorsalis* was also recorded by Chen (1978) as a new pest on corn.

Although significant information is available regarding host relations of *S. dorsalis*, very little work has been done on its basic biology in Taiwan. Chiu (unpublished data) shows that about 27 days are needed under 28°C in the laboratory to complete a generation of this species.

Thrips hawaiiensis

The flower thrips, *Thrips hawaiiensis*, is distributed throughout southern Asia and in limited parts of Africa, Australasia and the Pacific islands. This common flower-dwelling species attacks fruit crops, and cutflowers in Taiwan (Table 5). About 46 food plants were listed by Takahashi (1935, 1936). He noted that this thrips is the most dominant and polyphagous thrips in Taiwan, which attacks the flowers only and causes little injury to its host. Tang (1974) for the first time recorded *T. hawaiiensis* on banana in 1967 in Taiwan. Their feeding activity on the banana flowers does not cause any harm, but the egg-laying inside the epidermis of banana fingers, which subsequently leaves black pimples on the fruit skin, causes significant reduction in market value (Cheng et al. 1980). The damage on wax apple will also cause rough, pale color of fruit, thus reducing the quality (Chen, Z. C. 1981). *Thrips hawaiiensis* always stay in the flowers of citrus, where they may cause mechanical damage during egg-laying on the petals, ovaries or styles (Cheng 1985). However, after four years of studies, Ho (1987) proved that the damage of this thrips on citrus fruit is not significant. This thrips was found on peppers only at three locations (Taoyuan, Kaohsiung, Hualien), after surveying 11 counties in Taiwan (Su and Chen 1986). Besides damaging the young leaves or buds, *T. hawaiiensis* along with *S. dorsalis* also congregate and infest the flowers of mango (Lee and wen 1982). Meanwhile, the abundant thrips of this species and *Frankliniella formosae* significantly reduce the quality of cut flowers (Wang 1982a, b, c).

The life history of *T. hawaiiensis* on banana and citrus flowers has been described by Tang (1974) and Cheng (1985). In general, the lower the temperature, the longer is the life cycle. The species needs about 30 days to complete one generation under fluctuating temperature. Based on longer adult longevity, higher female ratio and more eggs laid, 20-25°C is suitable for *T. hawaiiensis*. The low threshold temperature for their development was 15°C (Tang 1974). The number of eggs laid per female is about 30-40.

Table 5. List of crops damaged by *Thrips hawaiiensis* (Morgan) in Taiwan.

Crops	Infesting parts on plant	Reference
Banana (*Musa sapientum*)	Flower, Fruit	Tang 1974; Cheng et al. 1980
Citrus (*Citrus* spp.)	Flower	Tsia 1984a; Cheng 1985
Grapevine (*Vitis vinifera*)	Leaf, Flower, Bud, Fruit	Shih 1989
Mango (*Mangifera indica*)	Flower, Leaf, Bud	Lee and Wen 1982; Lee 1983
Wax apple (*Syzygium samarangense*)	Flower, Fruit	Chen, Z. C. 1981
Chrysanthemum (*Chrysanthemum morifolium*)	Flower	Wang 1982c; Wang and Lin 1984;Liu 1984)
Gladiolus (*Gladiolus hybrida*)	Flower	Wang 1982b
Rose (*Rosa rugosa*)	Flower	Wang 1982a
Cucurbits	?	Wang et al. 1987
Green pepper, hot pepper (*Capsicum annuum*)	Flower	Su and Chen 1986
Leguminous plants	Flower	Chen 1979c
Tea (*Camellia sinensis*)	Flower	Chen 1979b

Rhipiphorothrips cruentatus

The grapevine thrips, *Rhipiphorothrips cruentatus*, is distributed throughout India, Sri Lanka, Pakistan and Afghanistan. It was first recorded in Taiwan by Chen, Z. C. (1981), who noted that this species caused serious damage on wax apple in Central Taiwan in 1978. Most of the 7000 ha of wax apple fields in the southern area of Taiwan were damaged by this thrips in 1984 (Chiu 1984a, b). This species mainly infests leaves of various fruit crops (Table 6). However, the leaves, flowers, buds, as well as fruits of grapevine were all damaged by it (Shih 1989).

Table 6. List of crops damaged by *Rhipiphorothrips cruentatus* Hood in Taiwan.

Crops	Infesting parts on plant	Reference
Grapevine (*Vitis vinifera*)	Leaf, Flower, Bud Fruit	Chang 1988, Shih 1989
Mango (*Mangifera indica*)	Mature leaves	Lee and Wen 1982; Lee 1988
Wax apple (*Syzygium samarangense*)	Leaf	Chen 1981; Chiu 1984a,b
Guava (*Psidium guajava*)	Leaf, Fruit	Chiu 1984a
Rose (*Rosa rugosa*)	Leaf	Chiu 1984a; Wang 1987

A parasite, *Ceranisus* sp., was found with as high as 77.2% parasitism in a wax apple field in southern Taiwan (Chiu 1984b). It may be the same species as *C. mensi* (Walker) described by Shih (1989), with 19.5 and 20.9% parasitism on gragevines in Taichung and Chi-Hu, respectively. Further studies on this parasite are warranted because it could be a good biocontrol agent in the future.

Frankliniella intonsa

The Taiwan flower thrips, *Frankliniella intonsa*, was recorded as *F. formosae* Moulton by Takahashi (1935, 1936) and Tsai (1965). Its importance was not noted until 1972, when it was found on green asparagus (Tang 1976b). This thrips is a polyphagous species with a characteristic flower preference. Tang (1976a) listed 25 species of plants fed on by *F. intonsa*. Of the various crops attacked by this thrips (Table 7), those on which it occurs most frequently and causes the most damage are garden peas (Wang 1990) and floriculture (Wang 1987) in Taiwan.

Tang (1976b) found 22 generations of this species in the laboratory in one year. Egg, larva and pupal stages of *F. intonsa* were recorded as 2.4, 3.5, and 2.2 days, respectively, while about 25-46 eggs were laid by each female.

Together with *T. hawaiiensis* and *Haplothrips chinensis* Priesner, this thrips was easily found on cut flowers (Wang and Lin 1984, Wang 1987). In addition *F. intonsa* constituted about 40% of thrips communities living on peppers (Su and Chen 1986). This thrips accounted for 19% of all thrips species in the asparagus fields (Tang 1975). Its population peaks can be found between October and May in the dry season (Fig. 1). *Frankliniella intonsa* also appeared, in small numbers, together with *Megalurothrips usitatus*, on soybean (Chang 1987a).

Only one insecticide (50% methamidophos) was recommended to control thrips on asparagus and rose (Table 3). Except for asparagus, other crops have not yet been reported seriously damaged by this thrips. The quarantine treatment of *F. intonsa* on cut flowers was the same as that of *T. hawaiiensis* (Wang 1982c; Wang and Lin 1984).

Table 7. List of crops damaged by *Frankliniella intonsa* Trybom in Taiwan.

Crops	Infesting parts on plant	Reference
Corn (*Zea mays*)	Flower	Chen 1978, 1984
Peanuts (*Arachis hypogaea*)	Leaf, Flower	Chen 1979c
Cucurbits	?	Wang et al. 1987
Garden peas (*Pisum sativum*)	Flower, Pod	Wang 1990
Green asparagus (*Asparagus officinalis*)	Flower, Bud, Stem	Tang 1975, 1976a,b
Mungbean (*Vigna radiata*)	Flower	Chen 1979c
Peppers (*Capsicum annuum*)	Flower	Su and Chen 1986
Soybean (*Glycine max*)	Leaf, Flower	Chen 1979c, Cheng 1987a
Chrysanthemum (*Chrysanthemum morifolium*)	Flower	Wang 1982c, Wang and Lin 1984
Rose (*Rosa rugosa*)	Flower	Wang 1982a

Thrips palmi

Thrips palmi is distributed throughout Asia, and is an important species attacking various vegetables. According to a 1990 survey (Chen, Z. C. pers. comm.) this species feeds on 105 different plants. Interestingly, this species had not been recorded in Taiwan until their damage on cucurbits in 1979 (in their report Wen and Lee (1982) incorrectly identified this species as *Thrips flavus* Schrank, which was later corrected by Chen, L. S). It has become an increasingly important pest of several Cucurbitaceae and Solanaceae crops in Taiwan (Table 8). This thrips is presumably an imported species.

Table 8. List of crops damaged by *Thrips palmi* Karny in Taiwan.

Crops	Infesting parts on plant	Reference
Cucurbitaceae	Leaf, Flower Shoot, Fruit	Wen and Lee 1982; Huang 1989, Wang et al. 1987; Wang 1990 Chen 1884
Eggplant (*Solanum melongena*)	Leaf, Flower Fruit	Su et al. 1985
Green pepper, hot pepper (*Capsicum annuum*)	Flower, Fruit,Bud	Su and Chen 1986

Thrips palmi infests the leaves and fruits of eggplant, green pepper, cucumber (Wang 1990) and wax gourd (Huang 1989). In addition, they prefer feeding on new shoots or young leaves of other cuburbits, and the buds, leaves and flowers of hot peppers can be damaged (Su and Chen 1986).Wang and Chu (1986) and Chen, Z. C. (unpublished data) conclude that *T. palmi* needs about 15 and 24 days to complete the immature and adult stage. In southern Taiwan, it takes 20-30 days for one generation and at least 10 generations occur on cucurbits per year (Wen 1984). The reproductive mechanism of *T. palmi* was recently studied. In general, females in parthenogenesis had shorter preoviposition duration and laid more eggs than those in sexual reproduction (Wang et al. 1989). There were no differences, at least on morphological and mating capability, between males produced by virgin and mated females (Chu and Wang 1990). Those females that mate immediately after emergence produced more male offspring. On the contrary, more female offspring were produced by those mated in 4-9 days after emergence (Wang and Chu 1990).

The population of *T. palmi* peaks in December and mid January on vegetable sponge (*Luffa cylindrica*) and cucumber, respectively, and decline during the wet season. On peppers in Hualien, *T. palmi* was dominant (92.01%) over the other four thrips species (*F. intonsa, T. hawaiiensis, S. dorsalis, Haplothrips chinensis*) (Su and Chen 1986). The density was higher during July to September. On wax gourd, the most preferred cucurbit, the high daily activity was found at 1700-1800 hours. White traps were most attractive when placed 0.5 m above the ground (Huang 1989). The population increased at late April-May and early October-November. *Thrips palmi* aggregated on eggplant leaves 75 cm above the ground (Su et al. 1985). They apparently inhabit the eggplant flowers throughout the year, with numerous thrips occurring in July.

In addition to 10 insecticides recommended for spraying on watermelon (Table 3), aldicarb 10G and carbofuran 3G were also suggested to give effective control of *T. palmi* (Wen and Lee 1983). The four other chemicals listed in Table 3 are good in controlling this thrips on eggplant.

Megalurothrips usitatus

The bean flower thrips, *Megalurothrips usitatus*, was not recognized until 1979 when the thrips on leguminous plants were studied (Chen 1979c). Previously this species might have been identified as *M. distalis*. The two thrips species causing damage on leguminous plants in Taiwan and reported by Takahashi as early as 1936, are: *Megalurothrips distalis* (Karny) (=*Taeniothrips distalis*) and *Megalurothrips formosae* (Moulton) (= *Taeniothrips formosae*) (Table 1). However, Chen (1979c) did not find any specimen of the above two species during a 1-year survey in the legume fields. Chang (1987a) also indicated that only *Megalurothrips usitatus* and *Frankliniella intonsa* were collected on soybean in southern Taiwan, with *M. usitatus* being the dominant species. The species *Taeniothrips distalis* recorded by Chen, W. S. (1980) and Yen (1984) on peanuts, or *M. distalis* found by Chen, Z. C. (1982), are the same species as *M. usitatus*.

Megalurothrips usitatus feeds on at least 28 species of plant (Chang 1987a). The flowers of various bean crops were mostly preferred (Table 9), while other parts of the plant can also be inhabited.

Table 9. List of Leguminosae plants damaged by *Megalurothrips usitatus* (Bagnall) in Taiwan (after Chang 1987a).

Leguminosae		Infesting parts on plant
Soybean	(*Glycine max*)	Leaf, Flower
Adzuki bean	(*Vigna angularis*)	Leaf, Flower, Pod
Mungbean	(*Vigna radiata*)	Leaf, Flower
Peanut	(*Arachis hypogaea*)	Leaf, Flower
Peas	(*Pisum sativum*)	Flower
Sword bean	(*Canavalia gladiata*)	Flower
Asparagus bean	(*Vigna sesquipedalis*)	Flower
Cowpea	(*Vigna sinensis*)	Flower
Yam bean	(*Pachyrhizus erosus*)	Leaf
Lima bean	(*Phaseolus limensis*)	Leaf, Flower
Snapbean	(*Phaseolus vulgaris*)	Flower
Indian Sesbania	(*Sesbania sesban*)	Leaf, Flower
	(*Cassia bicapsularis*)	Flower
Purple bauhinia	(*Bauhinia purpurea*)	Flower
Sun hemp	(*Crotalaria juncea*)	Flower
	(*Phaseolus atropurpureus*)	Flower
	(*Centrosema pubescens*)	Flower

Basic biological studies were done after the rearing method had been modified (Chang 1988c). The development of *M. usitatus* was studied at six constant temperatures from 14 to 30°C. In general, the egg, larval and pupal period and the adult longevity were 2-19, 5-10, 2-7 and 6-30 days, respectively. All the thrips died after hatching at the upper (30°C) and lower (14°C) temperatures. The suitable temperature for reproduction, therefore, appears to be around 20°C. Preference tests indicated that *M. usitatus* prefers feeding on the pollen of adzuki bean over the pollen of soybean and peanut (Chang 1988a). About 75% of the mature larvae were found pupating 1 cm under the soil surface when they were placed in sandy loam soils (Chang 1989).

Soybean, vegetable soybean and adzuki bean are usually planted in the winter season in southern Taiwan. The population fluctuations of both adults and nymphs of *M. usitatus* in four fields are presented in Fig. 1. The peak of thrips densities was recorded in early and mid December in adzuki bean field I and II, respectively. Obviously, the number of larvae increased rapidly in 5-7 days after the occurrence of an adult peak. Relatively more thrips occurred in early November on vegetable soybean and in late November and December on grain soybean. In fact, the movement of *M. usitatus* during the winter season occurred first in vegetable soybean fields in early November, then toward the adzuki bean field, where the thrips increased rapidly during early December. The thrips finally moved to grain soybean fields around late December (Chang 1988b).

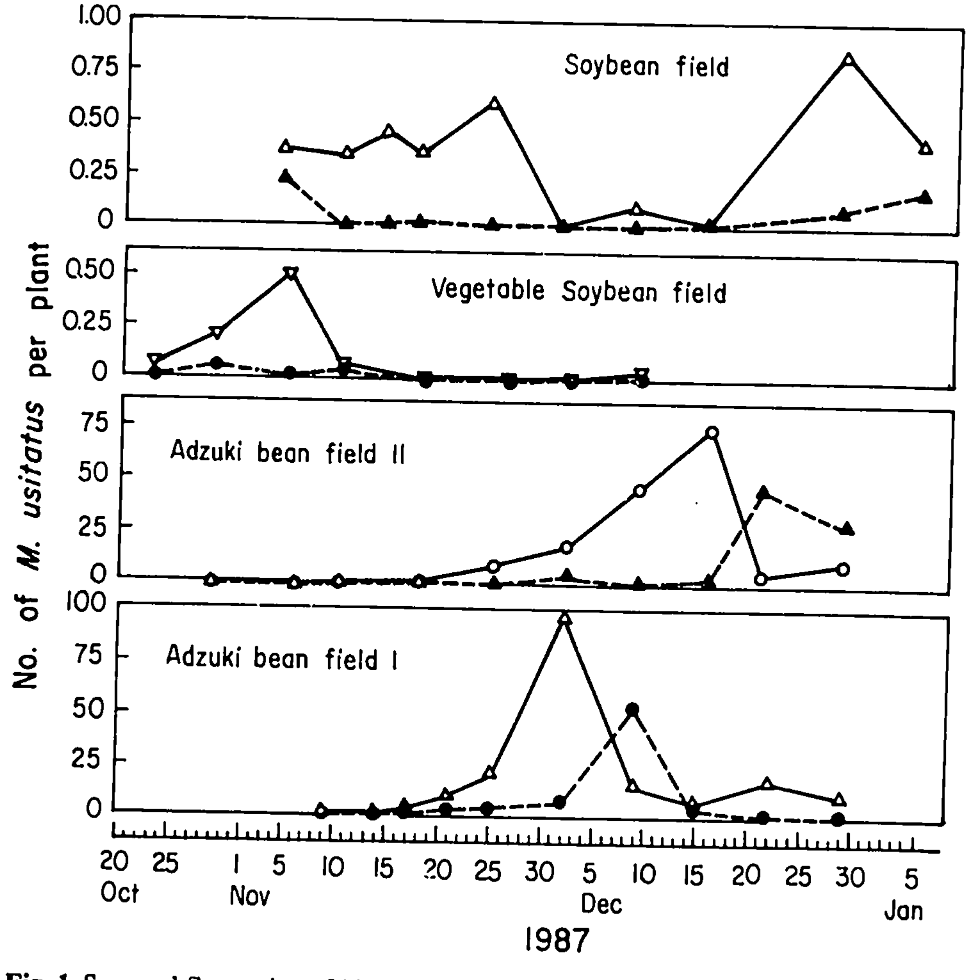

Fig. 1. Seasonal fluctuation of *Megalurothrips usitatus* on soybean, vegetable soybean and adzuki bean (after Chang 1988b). (Solid and broken lines represent adults and nymphs, respectively).

No chemical proved effective in controlling this thrips (Chang 1987b). The water traps with blue color were most attractive to *M. usitatus* (Chang 1990b). The efficiency of blue sticky traps in controlling them has been tested. In addition, a parasitic wasp *Ceranisus menes* (Walker) was found recently (Chang 1990a). However, studies on bionomics and its potential as a biocontrol agent are still required.

Thrips on Vegetables in Taiwan

Five common species of thrips, *T. palmi*, *T. hawaiiensis*, *T. tabaci*, *F. intonsa*, and *M. usitatus* infest vegetables in Taiwan (Chen and Chang 1987). The identification of eight important species of thrips on cucurbits was given by Wang et al. (1987). These include: *F. intonsa*, *M. typicus*, *M. usitatus*, *T. flavus*, *T. hawaiiensis*, *T. palmi*, *T. tabaci* and *Haplothrips chinensis*. Seven species of thrips were found on asparagus: *F. intonsa*, *F. tenuicornis*, *T. tabaci*, *T. floreus*, *Sericothrips obdoncinalis*, *S. dosalis*, and *Pseudodendrothrips mori*. Some of these species were incorrectly identified in the past (Tang 1975). Five species of thrips were found on peppers in Hualien: *T. palmi*, *F. intonsa*, *T. hawaiiensis*, *S. dorsalis*, and *H. chinensis* (Su and Chen 1986).

Twenty-seven species of thrips recorded on vegetable crops in Taiwan (Wang 1990) are listed in Table 10. Those that have the highest economic impact are: *T. palmi* on curcubits, eggplants, and bell pepper; *F. intonsa* on asparagus and garden pea; *T. tabaci* on green onion; and *M. usitatus* on beans.

Control of Thrips in Taiwan

Chemicals, in practice, are the major control measures of thrips in Taiwan. The list of officially recommended insecticides used on 11 crops is given in Table 3. However, based on their parthenogenesis and rapid reproduction, the use of insecticides is not an ideal means for controlling thrips. Other measures for controlling thrips have been studied: color traps on wax gourd (Huang 1989), grapevine (Shih 1989), and onion (Lu 1990), silver mulches in repelling onion thrips (Lu 1990), bags wrapped on mango fruit (Lee and Wen 1982) and grapevine (Shih 1989). However, these still need more evaluation and practical trials. Although the predatory and parasitic natural enemies such as *Triphleps sauteri* Poppius in pepper fields (Su and Chen 1986), *Ceranisus* sp. (Chiu 1984b) on wax apple, *C. menes* on grapevine thrips (Shih 1989) and bean flower thrips (Chang 1990a) have been identified, it could be difficult to develop biological control methods in open fields rather than in the greenhouse. For thrips with high mobility, polyphagous, and interstitial characteristics, the integrated use of chemical, cultural, physical as well as biological methods would be the best strategy to slow the thrips population growth. The following principles must be recognized in controlling thrips: (1) chemicals are not the answer, and should be used at the right time, using correct application methods and proper dosages; (2) weeds in the neighborhood of a target crop usually become the refuge of thrips, and should be considered at the same time when control is applied; (3) weeding or changing habitats of thrips by physical or cultural methods are sometimes effective in reducing thrips; (4) recognition of population dynamics and movement of thrips.

To deal with the increasing damage done by thrips on various crops, a symposium on thrips was held in September 1987. The proceedings contains a list of thrips in Taiwan (Chen 1987), as well as their ecology and rearing (Chiu 1987) and physical control (Chu 1987). Thrips on floriculture (Wang 1987), vegetables (Chen and Chang 1987), pulses and other grain crops (Chang 1987b) were also reviewed. A collaborative research team sponsored by the Council of Agriculture, Executive Yuan, was set up in 1990. The thrips included in the study are: *T. tabaci*, *T. palmi*, *T. hawaiiensis*, *S. dorsalis*, *M. usitatus* and *F. intonsa*. The studies of basic biology and ecology of thrips are the first priority, followed by damage evaluation on major crops attacked and finally selection and development of control measures.

Table 10. List of thrips on vegetables in Taiwan (after Wang 1990).

Thrips species	Major host plants
Terebrantia:	
Ayyaria chaetophora Karny [1]	Beans, cotton
Bathrips melanicornis (Shumsher Singh) [2]	Mungbean, mulberry, peppermint
Bolacothrips orientalis Priesner [1]	Green onion, onion
Frankliniella intonsa (Trybom) [1]	Beans, cucurbits, sweet potato, sugarcane
Megalurothrips distalis (Karny) [1]	Leguminosae
Megalurothrips formosae (Moulton) [1]	Sword bean
Megalurothrips typicus Bagnall [1]	Sponge gourd, mango, avocado, tobacco
Megalurothrips usitatus (Bagnall) [2]	Leguminosae
Scirtothrips dorsalis Hood [2]	Beans, peanuts, tea, tobacco, cotton, mulberry, rose, etc.
Taeniothrips alliorum Priesner [1]	Green onion, onion
Taeniothrips vitticornis Karny[1]	Beans
Taeniothrips clarus Moulton [1]	Radish
Taeniothrips kotoshoi Moulton [1]	Beans
Thrips addendus (Priesner) [2]	Soybean, chrysanthemum, rose
Thrips coloratus Schmutz [2]	Beans, onion, tobacco, tea, chrysanthemum, rose
Thrips flavus Schrank [1]	Beans, onion, cucumber, etc.
Thrips inferus Chen [2]	Soybean
Thrips hawaiiensis (Morgan) [1]	Beans, cucurbits, onion, corn
Thrips palmi Karny [3]	Cucurbits, beans, bell pepper, eggplant, potato
Thrips tabaci Lindeman [1]	Green onion, onion, tobacco, cotton
Tubulifera:	
Haplothrips aculeatus Fabricius [1]	Green onion, spinach, rice, corn, sugarcane
Haplothrips allii Priesner [1]	Green onion
Haplothrips certus Priesner[1]	Green onion
Haplothrips chinensis Priesner [1]	Green onion, radish, beans, sponge gourd
Haplothrips ganglbaueri Schmutz [2]	Broad bean
Haplothrips gowdeyi Franklin [1]	Green onion, celery, corn, chrysanthemum
Haplothrips vernoniae Karny [1]	Cucumber, sweet potato

[1] Tsai 1965; [2] from Chen 1979c; [3] Wang and Chu 1986b.

References

Ananthakrishnan, T. N. 1979. Biosystematics of Thysanoptera. Ann. Rev. Entomol., 24, 159-183.

1980. Thrips. *In* Harris, K. F., and Maramorosch, K. (ed.) Vectors of plant pathogens. Academic Press, N.Y., 149-164.

1984. Bioecology of thrips. Indira Publishing House.

Chang, C. P. 1988. The ecology and control of insects and other animal pests on grapevine. Chinese J. Entomol. Spec. Publ. 2, 11-31 (in Chinese with English summary).

Chang, L. C. 1973. Soil treatment with granular insecticides against onion thrips, *Thrips tabaci* Lindeman. Agr. Res., 22,285-289 (in Chinese with English summary).

Chang, N. T. 1987a. Seasonal abundance and developmental biology of thrips *Megalurothrips usitatus* on soybean at southern area of Taiwan. Plant Prot. Bull., 29, 165-173.

1987b. The damage and control of thrips (Insecta: Thysanoptera) on root crops, pulses and other grain crops. Chinese J. Entomol. Special Publ., 1, 55-72 (in Chinese with English summary).

1988a. The preference of thrips, *Megalurothrips usitatus* (Bagnall), for three leguminous plants. Plant Prot. Bull., 30, 68-77.

1988b. Population trends of *Megalurothrips usitatus* (Bagnall) (Thysanoptera: Thripidae) on adzuki bean and soybean examined by four sampling methods. Plant Prot. Bull., 30, 289-302.

1988c. Sandwich cage used for the pupation of bean flower thrips, *Megalurothrips usitatus* (Thysanoptera: Thripidae), larvae in laboratory. Natl. Pingtung Agr. Inst. Bull., 29, 52-57.

1989. Impacts of soil physical factors on the pupation of bean flower thrips, *Megalurothrips usitatus* (Bagnall) (Thysanoptera: Thripidae). Plant Prot. Bull., 31, 377-386.

1990a. *Ceranisus menes* (Walker) (Eulophidae: Hymenoptera), a new parasite of bean flower thrips, *Megalurothrips usitatus* (Bagnall) (Thripidae: Thysanoptera). Plant Prot. Bull., 32, 237-238.

1990b. Color preference of thrips (Thysanoptera: Thripidae) in the adzuki bean field. Plant Prot. Bull., 31 (in press).

Chen, L. S. 1976. A new genus and two new records of thrips (Thysanoptera: Terebrantia) from Taiwan. Plant Prot. Bull., 18, 242-249.

1977. The male of *Salpingothrips aimotofus* Kudo (Thysanoptera: Thripidae). Plant Prot. Bull., 19, 209-211.

1978. A field survey on the thrips of corn in Taiwan. Natl. Sci. Counc. Monthly, 6, 579-592 (in Chinese with English summary).

1979a. A new species of the genus *Ctenothrips* from Taiwan (Thysanoptera: Thripidae). Plant Prot. Bull., 21,184-187.

1979b. Thrips infesting tea in Taiwan. Plant Prot. Bull., 21, 377-382 (In Chinese with English summary).

1979c. Thrips of leguminous plants in Taiwan. Proc. Natl. Sci. Counc., ROC, 3, 414-428.

1980. Thrips associated with mulberry plant (*Morus* sp.) in Taiwan. Proc. Natl. Sci. Counc. ROC, 4, 169-182.

1981. Studies on the Panchaetothripiane (Thysanoptera: Thripidae) in Taiwan. Plant Prot. Bull., 23, 117-130.

1982. Studies on the subfamily Idolothripinae (Thysanoptera: Phlaeothripidae) in Taiwan. Phytopathol. Entomol. Natl. Taiwan Univ., 9, 53-67.

1984. The damage of thrips on various crops in Taiwan. Shinung Farm Magazine, 187, 10-14 (In Chinese).

1987. On the Taiwan thrips. Chinese J. Entomol. Special Publ., 1,1-7 (in Chinese with English summary).

Chen, W. S. 1980. A study on the relationship between thrips and the yield of peanut. Bull. Tainan DAIS, 14, 51-57 (in Chinese with English summary).

Chen, W. S., and Chang, F. I. 1987. The infestation of thrips on vegetables and their control. Chinese J. Entomol. Special Publ. 1, 45-53 (in Chinese with English summary).

Chen, Z. C. 1981. A survey study of the injurious insects of wax apple in Taiwan. Chinese J. Entomol., 2, 40-57 (in Chinese with English summary).

1982. Survey on the insect pests of adzuki bean in Taiwan. Pingtung Inst. Agr. Plant Prot. Bull., 4, 9-14 (in Chinese with English summary).

Cheng, E. Y., Hwang, M. T., Ruaan, J. C., and Tsai, T. C. 1980. Activity and spatial distribution of *Thrips hawaiiensis* Morgan, in banana plantation. Bull. Taiwan Banana Res. Inst., 1, 26-31 (in Chinese with English summary).

Cheng, M. F. 1985. Studies on morphology, life cycle and bionomics of the flower thrips (*Thrips hawaiiensis* (Morgan)) on citrus. Natl. Chia-I Agr. Inst. Bull., 12, 43-55 (in Chinese with English summary).

Chiu, H. T. 1984a. The thrips on wax apple. Shinung Farm Magazine 187, 24. (in Chinese).

1984b. The ecology and chemical control of grape-vine thrip (*Rhipiphorothrips cruentatus* Hood) on wax apple. Plant Prot. Bull., 26, 365-378 (in Chinese with English summary).

1987. The ecology and rearing methods of thrips. Chinese J. Entomol., Special Publ. 1, 9-26. (In Chinese with English summary).

Chu, Y. I. 1987. Physical control of thrips. Chinese J. Entomol. Special Publ., 1, 27-36 (in Chinese with English summary).

Chu, Y. I., and Wang, C. L. 1990. The reproductive mechanism of *Thrips palmi* Karny. II. Comparison of male reproduced parthenogenetically and bisexually. Chinese J. Entomol., 10, 79-87 (in Chinese with English summary).

Fang, M. N. 1960. Primary study on the ecology of onion thrips.. *In* Yen, D.F. (ed.) Proceedings of a symposium on insect pest of vegetable. Publ. by Natl. Taiwan Univ., 63-64 (In Chinese).

Ho, K. Y. 1987. An investigation of the influence of the flower *Thrips hawaiiensis* (Morgan), on the fruiting of citrus and its chemical control. Chinese J. Entomol., 7, 17-23 (in Chinese with English summary).

Huang, K. C. 1989. The population fluctuation and trapping of *Thrips palmi* in waxgourd. Bull. Taichung DAIS, 25, 35-41 (in Chinese with English summary).

Lee, H. S. 1984. The thrips on mangoes. Shinung Farm Magazine, 187, 16-18 (in Chinese).

1988. The ecology and control of the insect pests of mango. Chinese J. Entomol. Spec. Publ., 2, 71-79 (in Chinese with English summary).

Lee, H. S., and Wen, H. C. 1982. Seasonal occurrence of and injury caused by the thrips and their control on mangoes. Plant Prot. Bull., 24, 179-187. (in Chinese with English summary).

Lewis, T. 1973. Thrips, their biology, ecology and economic importance. London: Academic Press, 349 p.

Liu, T. S. 1984. The thrips on chrysanthemum and their control. Shinung Farm Magazine, 187, 31-32 (in Chinese).

Lu, F. M. 1989. The activity and preliminary estimated population density of onion thrips in the field. Chinese J. Entomol., 9, 21-26 (in Chinese with English summary).

1990. Color preference and using silver mulches to control the onion thrips, *Thrips tabaci* Lindeman. Chinese J. Entomol., 10, 337-342 (in Chinese with English summary).

Lu, F. M., and Lee, H. S. 1985. The infestation and chemical control of onion thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae). J. Agr. Res. China, 34, 223-227 (in Chinese with English summary).

1987. The life history and seasonal occurrence of onion thrips (*Thrips tabaci* Lindeman). J. Agr. Res. China, 36, 118-124 (in Chinese with English summary).

Shelton, A. M., and North, R. C. 1986. Species composition and phenology of Thysanoptera within field crops adjacent to cabbage fields. Environ. Entomol., 15, 513-519.

Shieh, J. L. 1988. The ecology of the major insect pests and their control on sugar apple (*Annona squamosa*). Chinese J. Entomol. Spec. Publ., 2, 117-132 (in Chinese with English summary).

Shieh, J. L., and Sheen, C. M. 1988. The seasonal fluctuation of major insect pests of *Annona squamosa* and their control. In Chen, Y.W., Pan, W.S., and Yang, C.S. (ed.) Proceedings of sugar apple research. Publ. by Taitung DAIS, Taiwan, 86-97 (in Chinese with English summary).

Shih, H. P. 1989. Injury habits of *Rhipiphorothrips cruentatus* Hood and the environmental factors affecting its population fluctuation. Master's Thesis. Natl. Chung Hsing Univ. Taiwan. 72 p. (in Chinese with English summary).

Su, C. Y., Chiu, T. S., and Lin, Y. J. 1985. Study of population fluctuation of *Thrips palmi* and its insecticidal control in the field on eggplant. Chinese J. Entomol., 5, 119-128 (in Chinese with English summary).

Su, H. P., and Chen, L. S. 1986. Thrips associated with peppers and their control. Bull. Hualien DAIS, 2, 73-85 (in Chinese with Engish summary).

Taiwan Provincial Government. 1990. Plant protection manual. Taiwan Provincial Government Publ. 562 p.

Takahashi, R. 1935. Economic aspects of the Formosan thrips. J. Soc. Trop. Agr. Formosa, 7, 67-78 (in Japanese).

1936. Thysanoptera of Formosa. The Philippine J. Sci., 60, 427-459.

Tang, C. C. 1973. Studies on the ecology of vine thrips and its control. In TARI Ann. Rep. 1972, Taiwan Agr. Res. Inst. 161 (in Chinese).

1974. The ecology study of banana thrips in Taiwan. Res. Bull. Natl. Sci. Inst., 7, 371-383 (in Chinese with English summary).

1975. Studies on the population dynamics and control of asparagus thrips. In Res. Rept. of asparagus cultivation. Publ. Dept. of Agr. and For., Taiwan Provincial Government, ROC 60-62 (in Chinese with English summary).

1976a. Preliminary survey of thrips infesting green asparagus in Taiwan. J. Agr. Res. China, 25, 37-43 (in Chinese with English summary).

1976b. Ecological studies on the important green asparagus thrips (*Frankliniella intonsa* Trybom) in Taiwan. J. Agr. Res. China, 25, 299-309 (in Chinese with English summary).

Tsai, Y. P. 1965. List of phytophagous insects in Taiwan. Plant Quarantine Bull. No. 5. Bureau of Commodity Inspection & Quarantine, Taiwan, ROC, 278 p. (in Chinese).

1984a. The thrips on citrus. Shinung Farm Magazine, 187, 22-23 (in Chinese).

1984b. The banana thrips, *Thrips hawaiiensis*. Shinung Farm Magazine, 187, 25 (in Chinese).

Wang, C. S. 1952. Study of cane thrips. Taiwan Sugar Industry Seasonal J., 90-107.

Wang, C. L. 1982a. Insect pests and their injury on rose. J. Agr. Res. China, 31, 97-101 (in Chinese with English summary).

1982b. Insect pests and their injuries on gladiolus in Taiwan. J. Agr. Res. China, 31, 173-176 (in Chinese with English summary).

1982c. Chemical control of insects on chrysanthemum cutflower. J. Agr. Res. China, 31, 339-346 (in Chinese with English summary).

1987. The infestation of thrips on floriculture and their control. Chinese J. Entomol., Spec. Publ., 1,37-43 (in Chinese with English summary).

1990. Thrips on vegetable crops. Chinese J. Entomol. Spec. Publ. No. 4, 70-94 (in Chinese with English summary).

Wang, C. L., and Chu, Y. I. 1986. Rearing method of southern yellow thrips, *Thrips palmi* Karny, in laboratory. Plant Prot. Bull., 28, 407-411 (in Chinese with English summary).

1990. The reproductive mechanism of *Thrips palmi* Karny. III. Development and sex ratio of individuals reproduced parthenogenetically and bisexually. Chinese J. Entomol., 10, 125-132 (in Chinese with English summary).

Wang, C. L., Chu, Y. I., and Lo, K. C. 1989. The reproductive mechanism of *Thrips palmi* Karny. I. The female ovipositional behavior. Chinese J. Entomol., 9, 251-261 (in Chinese with English summary).

Wang, C. L., and Lin, R. T. 1984. Study on the quarantine treatments of insect pests on chrysanthemum cutflowers - Fumigation and smoking methods. J. Agr. Res. China, 33, 88-93 (in Chinese with English summary).

Wang, C. L., Lo, K. C., and Chu, Y. I. 1987. The identification of thrips on cucurbits. J. Agr. Res. China, 36, 429-434 (in Chinese with English summary).

Wen, H. C. 1984. The important thrips on cucurbit crops. Shinung Farm Magazine, 187, 28-30 (in Chinese)

1988. Insects pests and their injuries on Indian jujube. Chinese J. Entomol. Spec. Publ., 2, 107-116.

1989. The distribution and control of grapevine thrips (*Rhipiphorothrips cruentatus* Hood) on waxapple. J. Agr. Res. China, 38, 100-103 (in Chinese with English summary).

Wen, H. C., and Lee, H. S. 1982. Field studies on cucurbit thrips (*Thrips flavus*) and its control. J. Agr. Res. China, 31, 89-96 (in Chinese with English summary).

1983. Effects of granular insecticides on the control of some pests during early growth stage of watermelon plants. J. Agr. Res. China, 32, 155-160 (in Chinese with English summary).

1984. The main insect pests on passion fruit in Taiwan. J. Agr. Res. China, 33, 81-87 (in Chinese with English summary).

Yen, F. C. 1984. The occurrence and control of thrips on peanuts. Shinung Farm Magazine, 187, 26-27 (in Chinese).

Discussion

Y. Hirose: There are two types of fruits of eggplants; long fruit and round fruit. I think in long fruit injury by *Thrips palmi* is more serious than the round fruit. Are there round fruit eggplant varieties in Taiwan?

N.T. Chang: There are no round fruit eggplants in Taiwan, so we don't have an opportunity to compare damage in these two kinds of eggplants.

J.G.M. Vos: Which stages of thrips are more damaging/voracious: adult or nymphs? Have you studied the transmission of viruses other than TSWV by thrips?

N.T. Chang: Both adults and nymphs can damage leaves of a crop, while in the flower-dwelling thrips the nymphs cause relatively severe damage. No.

E.N. Bernardo: How do the thrips reach the inner layers of the banana blossom?

N.T. Chang: By penetration through the edge of the flower buds.

K. Bansiddhi: In guava, you showed infestation only on leaf and fruit; what about on the flower? What are the flight activities of *Scirtothrips dorsalis* and *T. palmi*?

N.T. Chang: It seems that most *R. cruentatus* are found on leaves of crops, and very few on fruit or flowers. I have no information about flight activities of thrips at this time.

S. Poonchaisri: I think rearing thrips is very difficult, so would you please explain the technique for rearing some thrips that feed on flowers?

N.T. Chang: There are two Japanese papers about feeding thrips on pollen, and one paper on the technique that we used to rear *M. usitatus* in the laboratory.

Pest Status and Biological Control of *Thrips palmi* in Southeast Asia

Yoshimi Hirose
Division of Insect Natural Enemies
Institute of Biological Control
Faculty of Agriculture
Kyushu University, Fukuoka 812
Japan

Abstract

Heavy outbreaks of *Thrips palmi* Karny have occurred on fruit vegetables and other crops for the past 10 years in some areas of Southeast Asia. This recent increase in thrips is probably due to an exclusion of natural enemies after insecticide applications. This view is supported by the results of field surveys of natural enemies of *T. palmi* in Thailand, and field experiments on effects of insecticide applications on the abundance of *T. palmi* and its natural enemies in Japan. It is concluded that naturally occurring biological control of *T. palmi* could be important in Southeast Asia.

Introduction

Thrips palmi Karny is an important pest of fruit vegetables and many other crops in Southeast Asia. However, this thrips was not recognized as an important pest until more than 50 years after it was described from Indonesia in 1925. Heavy outbreaks of *T. palmi* have been recorded from different areas of Southeast Asia since about 1980.

This paper addresses the change of status of *T. palmi* and stresses the importance of naturally occurring biological control of this pest in Southeast Asia. The incidence of *T. palmi* on crops in this region is documented. An explanation of the reasons for the resurgence of *T. palmi* during the past 10 years, due to elimination of its natural enemies after insecticide applications, is provided.

Incidence of *T. palmi*

Thrips palmi was described as a new species from Sumatra by Karny (1925), where it was observed infesting tobacco plants. Dammerman (1929) also stated that *T. palmi* is the most common thrips on tobacco in Java and Sumatra. The incidence of this polyphagous species on other crops, and its outbreaks, had not been recorded from Southeast Asia until an outbreak on watermelon in the Philippines in 1977. Medina (1980) reported that this outbreak destroyed almost 80% of the watermelon plantations in Central Luzon and Laguna. In the Philippines, a heavy outbreak of *T. palmi* also occurred on cotton in 1978 (Schmutterer 1978). Bournier (1983) showed that *T. palmi* was still important as a pest of cotton in the Philippines in 1983. *Thrips palmi* became a serious pest of cotton in certain areas of Thailand in 1978 or 1979 (Wangboonkong 1981).

During 1987-88, surveys of natural enemies of *T. palmi* were made in Thailand, Malaysia and the Philippines (Hirose 1990). The incidence of this species on different kinds of fruit vegetables was recorded. Infestations of *T. palmi* on fruit vegetables were associated with insecticide applications in the countries surveyed (Kajita et al. unpublished data). The most serious infestation by *T. palmi* was observed in the Philippines; heavy outbreaks on watermelon and muskmelon occurred in gardens sprayed with insecticides in the suburbs of Manila in January 1987. Heavy outbreaks of *T. palmi* in Thailand were found on two gardens of cucumber in Suphan Buri in June 1987. Insecticide was applied in one of the two gardens. According to observations in Thailand, *T. palmi* infestations on eggplant were not so serious if eggplant gardens were not treated with insecticides. Thus, the infestations on eggplant tended to be less serious in home gardens where insecticides were never or rarely applied. An outbreak of *T. palmi* on eggplant in Penang, Malaysia, was observed in a truck garden sprayed with an insecticide every week in November 1987.

Effective Natural Enemies of *T. Palmi* and Insecticide Applications

Natural enemies of *T. palmi* had not been recorded from Southeast Asia until they were discovered in Thailand during 1987-88. Among eight species discovered, the eulophid larval parasitoid *Ceranisus menes* (Walker) and the anthocorid larval predator *Bilia* sp. were evaluated as effective natural enemies of *T. palmi* in Thailand (Hirose 1990; Hirose et al. unpublished data). A field survey of parasitism of *T. palmi* by *C. menes* was made on eggplant gardens in Thailand in 1988, often showing 40-60% in home gardens but negligible in truck gardens. This suggests a detrimental effect of insecticide application on parasitism by *C. menes*, since truck gardens are usually sprayed with insecticides for commercial production. The results of the survey also showed that the abundance of *T. palmi* was never higher in unsprayed gardens than in those sprayed with insecticides, suggesting the effectiveness of *C. menes* as a natural enemy of *T. palmi* in unsprayed gardens. Based on more extensive surveys of the abundance of *T. palmi* on eggplant in Thailand in 1987, Kajita et al. (unpublished data) demonstrated that the abundance was often higher in sprayed gardens than in unsprayed gardens. This phenomenon could be explained by the resurgence of *T. palmi* followed by an exclusion of *C. menes* and other natural enemies of *T. palmi* from sprayed gardens after insecticide applications.

A similar resurgence of *T. palmi* was observed in some experiments conducted in Japan, involving its native larval predator *Orius* sp. This predator is known to be effective against *T. palmi* on eggplant in Japan (Nagai et al. 1988; Kawamoto and Kawai 1988) and may be comparable to the effectiveness of *Bilia* sp. in Thailand. In an experiment, Nagai et al. (1988) showed that the population density of *T. palmi* increased rapidly on potted young eggplants infested with *T. palmi* and *Orius* sp. when the plants were treated with fenthion, but that the population density of the thrips on the plants without chemical treatment remained at a very low level. Nagai (1990) conducted a similar experiment in an eggplant garden and observed *T. palmi* resurgence induced by an exclusion of *Orius* sp. at a plot treated with insecticide. Hirose et al. (unpublished data) demonstrated experimentally that population density of *T. palmi* in an eggplant garden sprayed with cypermethrin was about 10 times that in an unsprayed eggplant garden, evidence of *T. palmi* resurgence being responsible for the exclusion of *Orius* sp. from the sprayed garden.

Ceranisus menes is native to Japan, but it was not known as a parasitoid of *T. palmi* until 1988, when *C. menes* was observed parasitizing *T. palmi* nymphs on eggplant near Fukuoka. Hirose et al. (unpublished data) showed that the parasitism by *C. menes* of *T. palmi* nymphs in autumn 1988 was often high in home gardens. This phenomenon is similar to that in Thailand, suggesting that *T. palmi* populations increased as a result of the destruction of *C. menes* by insecticide applications. Although no field experiment has been attempted to confirm the host resurgence in this host-parasitoid system, in Japan destruction of *C. menes* could be related to *T. palmi* resurgence in autumn when *Orius* sp. is not so active as a predator of *T. palmi*.

Conclusions

Thrips palmi increased in number and caused serious damage to different crops around 1980 in some areas of Southeast Asia. At almost the same time it invaded Japan in 1978, New Caledonia in 1979, and Hawaii in 1982 (Sakimura et al. 1986). Bournier (1986) explained the increase in distribution area of *T. palmi* and severity of damage by this thrips by an appearance of a noxious mutation type causing these phenomena. However, there is no evidence to support his explanation. Some other explanations may be possible, but I suggest that the increased incidence of *T. palmi* in Southeast Asia could be the result of increased insecticide applications in some areas of this region for the past 10 years. The higher population density of *T. palmi* increased its chances to expand into other areas. As stated earlier, the mechanism of the resurgence of *T. palmi* involves destruction of its effective natural enemies. In Southeast Asia, most of the insecticides used for the control of pests other than *T. palmi* in fact contribute to its resurgence. This shows the importance of naturally occurring biological control agents of *T. palmi* in Southeast Asia. It is consistent with the fact that *T. palmi* is native to Southeast Asia and thus has effective natural enemies native to this region. Neither classical biological control of *T. palmi* nor inundative release of its natural enemies is necessary for Southeast Asia. Strategies for controlling *T. palmi* in this region should be explored, based on its naturally occurring biological control.

Acknowledgments

I thank Dr. H. Kajita for his helpful comments on this manuscript.

References

Bournier, J.P. 1983. A polyphagous insect: *Thrips palmi* Karny, an important cotton pest in the Philippines. Cot. Fib. Trop., 38, 288-289.

1986. On the geographical distribution of *Thrips palmi* Karny. Cot. Fib. Trop., 41, 60-61.

Dammerman, K.W. 1929. The Agricultural Zoology of the Malay Archipelago, The Animals Injurious and Beneficial to Agriculture, Horticulture and Forestry in the Malay Peninsula, the Dutch East Indies and the Philippines. J.H. de Bussy Ltd., Amsterdam, 473 p.

Hirose, Y. 1990. Prospective use of natural enemies to control *Thrips palmi* (Thysanop., Thripidae). In Bay-Petersen, J. (ed.) The use of natural enemies to control agricultural pests. FFTC, Taipei, 135-141.

Karny, H.H. 1925. Die an Tabak auf Java und Sumatra angetroffenen Blasenfusser (Thysanoptera). Bull. Deli Proefstation, 23, 3-55.

Kawamoto, K., and Kawai, A. 1988. Effect of *Orius* sp. (Hemiptera: Anthocoridae) on the population of several pests on eggplant. Proc. Assoc. Pl. Prot. Kyushu, 34, 141-143 (in Japanese with English summary).

Medina, J.R. 1980. Effective insecticide against melon thrips. Plant Prot. News, 9(2-4), 6-7.

Nagai, K. 1990. Suppression effect of *Orius* sp. (Hemiptera: Anthocoridae) on the population density of *Thrips palmi* Karny (Thysanoptera:Thripidae) in eggplant in an open field. Jpn. J. Appl. Ent. Zool., 34, 109-114 (In Japanese with English summary).

Nagai, K., Hiramatsu, T., and Henmi, T. 1988. Predatory effect of *Orius* sp. (Hemiptera: Anthocoridae) on the density of *Thrips palmi* Karny (Thysanoptera:Thripidae) on eggplant. Jpn. J. Appl. Ent. Zool., 32, 300-304 (in Japanese with English summary).

Ruhendi, and Litsinger, J.A. 1979. Insect-suppressing effect of rice stubble height, tillage practices, and straw mulch in a wetland rice-cowpea cropping pattern. Intern. Rice Res. Newsletter, 4(3), 26-27.

Sakimura, K., Nakahara, L.M., and Denmark, H.A. 1986. A thrips, *Thrips palmi* Karny (Thysanoptera:Thripidae). Ent. Circ. Florida Dept. Agr. Consum. Serv. Div. Plant Indus. No. 280, 4 p.

Schmutterer, H. 1978. Cotton Pests in the Philippines. Germ. Agency Tech. Cooperation, Eschborn, 110 p.

Wangboonkong, S. 1981. Chemical control of cotton insect pests in Thailand. Trop. Pest Manage., 27, 495-500.

Discussion

K. Bansiddhi: Do you think the natural enemies which you mentioned (e.g. *Ceranisus menes*, *Bilia* sp.) of *Thrips palmi* can be effective on other species of thrips?

Y. Hirose: These natural enemies are polyphagous, so I think they can affect other species of thrips as control agents.

E.N. Bernardo: When thrips infestation is preceded by occurrence of another pest on the crop which needs application of pesticide, will it not be a good idea to release laboratory-reared natural enemies of thrips to start a natural enemy population buildup? Has there been any work on mass-rearing of *T. palmi* predator particularly *Orius*?

Y. Hirose: I do not know. Laboratory rearing of natural enemies of thrips is important because it has never been successful. In Japan Dr. Kawai tried to do mass-rearing of *Orius* sp. using skim milk but there is the problem of cannibalism. Further studies are needed.

J.M.G. Vos: Has there be' ı research ɔn insecticides not affecting natural enemies of *Thrips palmi*? This is related to the other insect pests besides thrips that in farmers' practice have to be controlled too.

Y. Hirose: No, there has been no research. This work is needed, and my colleagues and I are planning to do research along this line.

S. Sastrosiswojo: Is *Ceranisus menes* host-specific, and is it found also in Indonesia?

Y. Hirose: This parasitoid is known to be polyphagous. In Japan, it has been reported to have several host species of thrips It is also recorded from Java.

Thrips on Pepper: AVRDC's Research Strategy

N. S. Talekar
Asian Vegetable Research and Development Center
Shanhua, Tainan 74199, Taiwan, ROC

Introduction

In recent years, thrips have become increasingly destructive in most crops, particularly in vegetables like pepper, cucurbits, eggplant, watermelon, onions, mungbean, etc. AVRDC is conducting breeding and plant protection-oriented research on two of these crops, pepper and mungbean. The third crop, onion, will soon be added to AVRDC's list of principal crops and breeding and plant protection research will be initiated on onion as well. Although AVRDC recognized the problem of thrips in mungbean as early as 1978 (AVRDC 1979) and, in fact, screened most of the mungbean germplasm for resistance to *Megalurothrips usitatus* (Bagnall), the research had to be discontinued due to the erratic occurrence of this pest. This infrequent occurrence made it difficult for us to screen germplasm for resistance or to confirm the resistance.

In 1986 AVRDC started research on pepper. Our initial survey of world literature on the insect and mite pests of pepper led us to conclude that species of thrips cause considerable damage over a much wider geographic area than any other group of pests (AVRDC 1990). Information gathered from our own travels in Asia and from scientists working in Asia has also led us to the same conclusions.

Therefore, in late 1989, a decision was taken to initiate research on thrips. We soon realized that the thrips that attack pepper (Table 1) also attack several other economically important crops (Table 2). Therefore, in order to develop sustainable integrated pest management (IPM) for thrips on pepper, due consideration needs to be given to these crops in the development of an IPM package. It would be impossible for us to do research on all the crops that are alternate hosts for the thrips that attack pepper. Since the thrips problem exists in our region and a fair amount of research on the control of thrips is already being conducted in the countries of Southeast Asia, AVRDC decided to organize a conference to assess the status of research on thrips in this region. We were specifically interested in assessing the strengths and weaknesses of research in each country and the possibility of collaborative research in the region, to better utilize available resources. We were also interested in developing our research strategies for the region. Our strategy will be modified depending upon the recommendations of the workshop.

AVRDC's Research Strategy

The crops

Among AVRDC's six principal crops (soybean, mungbean, Chinese cabbage, tomato, pepper and sweet potato), damage by thrips is more frequent in pepper than the rest. This is true in most of Asia. Our active research, therefore, will be on pepper. We realize that in certain other vegetables such as cucurbits, watermelon, eggplant, etc. thrips are equally damaging. However, these crops are not emphasized for research at AVRDC and will not be targeted for intensive thrips research. We will, however, compile literature on thrips that attack these crops because pepper may be an alternate host. If, as expected, AVRDC takes up onion as a principal crop, we will immediately start our thrips research on onion.

Thrips species

Among the 11 thrips species that are so far reported to feed on pepper (Table 1), *Scirtothrips dorsalis* Hood, *Thrips palmi* Karny and *Thrips tabaci* Lindeman are the most common in Asia. These species also occur in Taiwan. We will concentrate our research on these species. If other species become more important elsewhere but are not found in Taiwan, we will seek collaborative arrangements to cover research on these species.

Table 1. Geographic distribution of thrips associated with pepper.

Species	Location	Reference
Frankliniella cephalica bispinosa Morg	USA	Watson et al. 1937
Frankliniella intonsa (Trybom)	Taiwan	Su and Chen 1986
Frankliniella occidentalis	Netherlands	Staay and Uffelen 1988
Gynaikothrips karny Bagn	India	Ramakrishna Ayyar 1920
Haplothrips chinensis Priesner	Taiwan	Su and Chen 1986
Hercinothrips femoralis	USA	Smith and Goodhue 1945
Scirtothrips dorsalis Hood	Burma	Anonymous 1985
	India	Ramakrishna Ayyar 1929
	Sri Lanka	Fernando and Peiris 1957
	Taiwan	Su and Chen 1986
Taeniothrips simplex Morison	USA	O'Kane 1947
Thrips hawaiiensis (Morgan)	Taiwan	Su and Chen 1986
Thrips palmi Karny	Martinique	Denoyes et al. 1986
	Guadeloupe	Guyot 1988
	Japan	Kinjo et al. 1985
	Taiwan	Su and Chen 1986
Thrips tabaci Lindeman	Denmark	Hansen 1985
	Lebanon	Anonymous 1986
	USSR	Begunov and Storozhkov 1986
	Netherlands	Woets 1975
	India	Anonymous 1936
	Indonesia	Codhaas 1937
	Japan	Ishii 1933
	USA (Hawaii)	Sakimura 1940
Thrips spp.	Turkey	Goksu and Atak 1972

Research topics

Host-plant resistance, cultural control and biological control are among the researchable topics. Very little information exists on host-plant resistance to thrips in pepper. AVRDC holds about 6000 pepper accessions in its germplasm collection, and there exists the possibility of sources of resistance in this germplasm. With the multitude of thrips species and the erratic nature of their occurrence, the chances of success for host-plant resistance research in the immediate future are not bright. Although it will be our long-term goal to develop thrips-resistant pepper cultivars, this approach will not be emphasized in the initial stages. We will, however, do basic studies on the thrips host-plant interaction to develop a practical technique to screen pepper germplasm for resistance to thrips in the future.

We will review the past efforts on cultural control and pursue research to introduce improvements. There is enough evidence to indicate that thrips have become major pests recently because of the excessive use of chemical insecticides to control insect pests (Hirose 1990). Where chemical insecticide use is nonexistent or minimal, thrips are not a problem. This is believed to be due to the mortality of natural enemies when chemical insecticides are used versus the proliferation of natural enemies in insecticide-free areas. We will survey natural enemies of thrips and initiate active biological control research. We will import natural enemies from outside if such agents show potential in the control of thrips in our region.

Information dissemination

In order to help the national program researchers to carry out thrips research more effectively, we are compiling all available literature on thrips on vegetables in general and pepper in particular. We plan to publish an annotated bibliography in 1992 and also publish subsequent supplements whenever adequate additional literature becomes available. We will compile a directory of thrips researchers in the world and make it available to national programs. This will enable national program scientists to contact resource persons directly and, if necessary, seek assistance. To further improve communication we plan to organize the first international symposium on thrips. Thrips researchers from around the globe will be invited to participate in this conference, when we will seek to establish a biological control working group to emphasize research on this topic.

There seems to be a need to upgrade the research skills of some national program scientists to make them more productive as thrips researchers. We will attempt to organize a short-term refresher course by combining the resources and expertise of the region with those of specialists from outside the region where this is justified. Upgrading of research at the national program level through collaboration will enable individual nations to solve the thrips problem on their own.

Table 2. Host range of principal thrips species that attack pepper.

Thrips species	Hosts
Scritothrips dorsalis	Buckwheat (*Fagopyrum esculentum* Moench)
	Rose (*Rosa* spp.),
	Pear (*Pyrus sp.*),
	Peach (*Amygdalus persica* L.),
	Strawberry (*Fragaria chiloensis* Duch var. *ananassa* Hort.),
	Water berry (*Syzygium samarangense* Merr. et Perry),
	Jujub tree (*Ziziphus mauritiana* Lam.),
	Mango (*Mangifera indica* L.),
	Lichi tree (*Nephelium lichi* Cam.),
	Longan tree (*Nephelium longana* (Lam.) Cam.),
	Tea (*Camellia sinensis* (L.) Kuntze),
	Grape (*Vitis pteroclada* Hay.)
	Grape (*Vitis vinifera* L.),
	Persimon (*Diospyros kaki* L.),
	Asparagus (*Asparagus officinalis* L.),
	Peanut (*Arachis hypogaea* L.) ,
	Mungbean (*Vigna radiata* (L.) Wilczek),
	Soybean (*Glycine max* (L.) Merrill),

(Continued)

Thrips species	Hosts
	Snapbean (*Phaseolus vulgaris* (L.)),
	Raspberry (*Rubus* spp.),
	Corn (*Zea mays* L.),
	Citrus (*Citrus* spp.),
	Sweet potato (*Ipomoea batatas* (L.) Lam.),
	Dahlia (*Dahlia pinnata* Cav.),
	Cotton (*Gossypium* sp.)
Thrips palmi	Mulberry (*Morus latifolia* Poir),
	Carnation (*Dianthus caryophyllus* L.),
	Spinach (*Spinacia oleracea* L.),
	Pepper (*Piper nigrum* L.),
	Betel (*Piper betle* L.),
	Tea (*Camellia sinensis* (L.) Kuntze),
	Brassica sp.,
	Radish (*Raphanus sativus* L.),
	Peach (*Amygdalus persica* L.),
	Apple (*Pyrus* sp.),
	Plum (*Prunus salicina* Lindl.),
	Apple (*Malus sylvestris* Mill.),
	Soybean (*Glycine max* (L.) Merrill),
	Snapbean (*Phaseolus vulgaris* (L.)),
	Broadbean (*Vicia faba* L.),
	Adzuki bean (*Vigna angularis* Wight),
	Mungbean (*Vigna radiata* (L.) Wilczek),
	White clover (*Trifolium repens* L.),
	Peas (*Pisum sativum* L.),
	Oxalis spp.,
	Citrus (*Citrus* spp.),
	Grapes (*Vitis* spp.),
	Cotton (*Gossypium* sp.),
	Okra (*Hibiscus esculentus* L.),
	Cucumber (*Cucumis sativus* L.),
	Watermelon (*Citrullus vulgaris* Schrad.),
	Melon (*Cucumis melo* L.),
	Cucurbits (*Cucurbita* sp.),
	Wax gourd (*Benincasa cerifera* Savi.)
	Balsam pear (*Momordica charantia* L.),
	Gourd (*Luffa* spp.),
	Cucurbit (*Lagenaria siceraria* Stand.),
	Carrot (*Daucus carota* L.),
	Sweet potato (*Ipomoea batatas* (L.) Lam.),
	Perilla frutescens (L.),
	Eggplant (*Solanum melongena* L.),
	Potato (*Solanum tuberosum* L.),
	Tobacco (*Nicotiana tabacum* L.),
	Sesame (*Sesamum indicum* L.),
	Garland chrysanthemum (*Chrysanthemum morifolium* Ram.),
	Dahlia (*Dahlia pinnata* Cav.),
	Lettuce (*Lactuca sativa* L.),

(Continued)

Thrips species	Hosts
	Sunflower (*Helianthus annuus* L.),
	Corn (*Zea mays* L.),
	Buckwheat (*Fagopyrum esculentum* Moench),
Thrips tabaci	Oat (*Avena sativa* L.),
	Corn (*Zea mays* L.),
	Asparagus (*Asparagus officinalis* L.),
	Onion (*Allium cepa* L.),
	Welsh onion (*Allium fistulosum* L.),
	Poet's narcissus (*Narcissus tazetta* L. var. *chinensis* M. Roem),
	Garlic (*Allium sativum* L.),
	Chinese chive (*Allium odorum* L.),
	Gladiolus (*Gladiolus gandavensis* V. Houtte),
	Orchid (*Freesia refracta* Klatt),
	Mulberry (*Morus latifolia* Poir),
	Polygonum cespitosum Blume,
	Carnation (*Dianthus caryophyllus* L.),
	Opium poppy (*Papaver somniferum* L.),
	Cabbage (*Brassica oleracea* L.),
	Soybean (*Glycine max* (L.) Merrill),
	Indigo (*Indigofera tinctoria* L.),
	Lespedeza bicolor Turcz,
	Lima bean (*Phaseolus lunatus* L.),
	Peas (*Pisum sativum* L.),
	Mungbean (*Vigna radiata* (L.) Wilczek),
	Snapbean (*Phaseolus vulgaris* L.),
	White clover (*Trifolium repens* L.),
	Sour orange (*Citrus aurantium* L.),
	Perilla frutescens (L.),
	Tomato (*Lycopersicon esculentum* Mill.),
	Eggplant (*Solanum melongena* L.),
	Potato (*Solanum tuberosum* L.),
	Foxglove (*Digitalis purpurea* L.),
	Formosan elderberry (*Sambucus formosana* Nak.),
	Melon (*Cucumis melo* L.),
	Cucumber (*Cucumis sativus* L.),
	Chrysanthemum (*Chrysanthemum morifolium* Ram.),
	Cirsium spp.,
	Dahlia (*Dahlia rosea* Cav.)
	Gossypium sp.,
	Cyclamen persicum Mill.

References

Anonymous. 1936. Agriculture and Animal Husbandry in India 1933-34 and 1934-35, Part 1. Crop Production, New Delhi, 390 p.

1985. Burma-thrips. Quart. Newsl. FAO Asia Pacific Plant Prot. Comm., 28, 14-15.

1986. Crop protection news from Arab/Near East countries 1986. Arab Near East Plant Prot. Newsl., 3, 19-20.

AVRDC.1979. AVRDC Progress Report 1978. Asian Vegetable Research and Development Center, Shanhua, Taiwan, 173 p.

1990. 1987 Progress Report. Asian Vegetable Research and Development Center, Shanhua, Taiwan, 482 p.

Begunov, V. Z., and Storozhkov, Yu V. 1986. We are developing the biological method. Zach. Rast, 9, 8-9.

Coolhaas, C. 1937. Jaarverslag oogstjaar 1935-1936. Meded. Proefst Vorstanl. Tab. No. 84, 88 p.

Denoyes, B., Bordat, D., DeBon, H., and Daly, P. 1986. A new pest of vegetable crops in Martinique: *Thrips palmi* Karny. Agron. Trop., 41, 167-169.

Fernando, H. E., and Peiris, J. W. L. 1957. Investigations on the chilli leaf curl complex and its control. Trop. Agric., 113, 305-323.

Guyot, J. 1988. Review and first observations in Guadeloupe on *Thrips palmi* Karny. Agron., 8, 565-575.

Hansen, L. S. 1985. Biological control of glasshouse pests in Denmark: extent, economics and present research. Meded. Facult. Landouw. Rijk., 50, 399-402.

Hirose, Y. 1990. Prospective use of natural enemies to control *Thrips palmi* (Thysanop; Thripidae). 135-141. *In* Mochida, O., Kiritani, K., and Bay-Peterson, J. (ed.). The use of natural enemies to control agricultural pests. FFTC Book Series No. 40. Food and Fertilizer Technology Center for the Asian and Pacific Region, Taipei, Taiwan, ROC.

Ishii, T. 1933. Notes on two hymenopterous parasites of thrips in Japan. Kontyu, 7, 13-16.

Kinjo, T., Nakasone, T., Arasaki, M., Nagamine, Y., Suzuki, H., and Miyara, A. 1985. Integrated control of *Thrips palmi* on green pepper (*Capsicum annuum*) cultivated in a greenhouse. Proc. Assoc. Plant Prot. Kyushu, 31, 160-165.

O'Kane, W. C. 1947. Results with benzene hexachloride. J. Econ. Entomol., 40, 133-134.

Ramakrishna Ayyar, T. V. 1920. A note on our present knowledge of Indian Thysanoptera and their economic importance. Report, Proc. Third Entomol. Meeting, 2, 618-622.

1929. The economic status of Indian Thysanoptera. Bull. Entomol. Res., 20, 77-79.

Sakimura, K. 1940. Evidence for the identity of the yellow-spot virus with the spotted-wilt virus: Experiments with vector, *Thrips tabaci*. Phytopathol., 30, 281-299.

Smith, F. F., and Goodhue, L. D. 1945. DDT aerosols to control onion thrips and other pests in greenhouse. J. Econ. Entomol., 38, 173-179.

Staay, M. V. D., and Uffelen, J. V. 1988. Chemical control of California thrips. Dichlorvos can also be applied on cucumbers. Grooenten Fruit, 43E, 40-41.

Su, H. P., and Chen, L. S. 1986. Thrips associated with peppers and their control. Bull. Hualien Dist. Agric. Improv. Stn. No. 2, 73-85.

Watson, J. R., and others. 1937. Entomology. Rep. Florida Agric. Expt. Sta., 1935-36, 64-69.

Woets, J. 1975. Progress report on the integrated pest control in glasshouses in Holland. Glasshouse Crops Research and Experiment Station, Naaldwijk, The Netherlands. 34-38.

Recommendations

1. Biological control

Results of the studies in Japan demonstrate considerable potential for biological control of thrips. Natural enemies, especially predators and parasites, of some thrips species are available and biological control of these thrips species is feasible. It is, however, essential that systematic assessment of potential of these natural enemies be investigated. Following are potential areas for collaborative research:

(a) Develop methodology for mass rearing of thrips which will facilitate the rearing of parasites and predators. Predators, being nonspecific, can be reared with relative ease.

(b) Search for new parasites and predators of economically important thrips in the region.

(c) Investigate those fungi that seem to attack thrips. However, fungal infestation requires high humidity and thrips are important mainly in the dry season. We should, therefore, not place undue importance on the potential of this pathogen.

2. Cultural control

Mulching has potential in reducing thrips damage. At present the white-plastic mulch seems to reduce considerably thrips infestation. However, these mulching materials are expensive. There is need to substitute this plastic with other suitable and cheaper materials. There is also a need to do basic research on the mechanism by which white plastic mulches reduce thrips infestation.

Flooding seems to have potential in reducing thrips, presumably drowning thrips pupae in the soil. This approach should be studied.

Intercropping does not seem to have consistent effects on thrips populations. This approach, therefore, should not be emphasized.

To reduce thrips infestations at seedling stage, which reduces plant vigor later on, workshop participants recommend that the seedlings be raised inside a fine-mesh net cover, fine enough to exclude thrips.

Colored paper/plastic sheets seem to attract thrips. Potential of such treatments should be thoroughly investigated.

Excessive use of fertilizer which increases vegetative growth beyond the normal needs of the plant should be discouraged. Excessive growth does not increase yield but it does provide shelter for thrips.

3. Host-plant resistance

The erratic nature of infestation of thrips makes screening for host-plant resistance difficult. The group recommends, however, that breeding for resistance to other insect pests such as *Spodoptera* spp. or shoot and fruit borer in eggplant, control of which requires application of insecticides, should be emphasized. The crop varieties resistant to these pests will reduce the need for the use of insecticides which will not aggravate the thrips problem. Nonchemical control of other pests will similarly help in preventing thrips outbreaks.

4. Taxonomy

Clarification of the taxonomic status of different thrips species found in the region should be undertaken as soon as possible. AVRDC should identify the sources of thrips identification services. Interested scientists could send their thrips collection to AVRDC, which in turn will send the samples for identification to scientists in the region. For each sample sent abroad a type specimen would be deposited with the thrips taxonomist at the Department of Agriculture, Thailand. The identity of the specimen from Taiwan, Japan, and Thailand would be corroborated. In future, the Thai taxonomist would serve the identification needs of the region.

5. Virus transmission

It is essential to know which viruses are transmitted by particular thrips species. We recommend that, where feasible, entomologists and virologists work together to clarify the situation for the benefit of the larger scientific community, and to develop an IPM program for both thrips and virus diseases.

6. Sampling

Sampling for representative thrips populations remains a problem. Different researchers use different sampling techniques which makes comparison of the data difficult. At present, due to the lack of a standard method, sampling of thrips in flowers, as in the case of pepper, appears to be more common. Efforts need to be made to develop a standard methodology to sample thrips in all economically important crops.

7. Training needs

Since thrips species have become serious pests only in the recent past, national programs are forced to assign researchers - who are not trained in thrips research - to handle the research and development activities in thrips. Universities rarely emphasize teaching of thrips research at the BSc level. This has created a serious shortage of technical personnel which is hindering progress in developing IPM for thrips. The workshop participants request that AVRDC seek funds to conduct a training course for the region to train junior scientists in research on thrips.

8. Information exchange

Availability of up-to-date literature is very important to learn new techniques, avoid duplication of research and develop IPM programs. AVRDC should look into the possibility of acquiring an up-to-date data base on thrips and make it available to the researchers in the region. A global conference to discuss this worldwide insect problem should be convened soon. The exchange of new information during such a conference would be very useful. The workshop participants suggest that AVRDC play a leading role in the organization of such a meeting.

9. Pesticide use

The participants expressed concern over the excessive use of chemical insecticides to control insect pests that coexist with thrips. Such insecticide use has exacerbated the thrips problem. It is important that while planning for such insecticide applications, care should be taken that such operations should not aggravate the thrips problem.

Participants

Korbkiati Bansiddhi, Vegetables and Ornamental Plants Insect Pests Research Group, Division of Entomology and Zoology, Department of Agriculture, Bangkhen, Bangkok 10900, Thailand.

E. N. Bernardo, Department of Entomology, University of the Philippines at Los Baños, College, Laguna, Philippines.

N. T. Chang, Department of Plant Protection, National Pingtung Institute of Agriculture, Pingtung 91207, Taiwan, ROC.

Yoshimi Hirose, Institute of Biological Control, Faculty of Agriculture, Kyushu University, Fukuoka 812, Japan.

Fauziah Haji Ismail, MARDI Station, Jalan Kebun, P.O. Box 186, 41720 Klang, Selangor, Malaysia

Reginald MacIntyre, AVRDC, P.O. Box 42, Shanhua, Tainan 74199, Taiwan, ROC

Sirinee Poonchaisri, Division of Entomology and Zoology, Department of Agriculture, Bangkhen, Bangkok 10900, Thailand

Sudarwohadi Sastrosiswojo, Lembang Horticultural Research Institute, Jalan Tangkuban Parahu 517, Lembang-Bandung 40391, Indonesia

N. S. Talekar, AVRDC, P.O. Box 42, Shanhua, Tainan 74199, Taiwan, ROC

Janny Vos, Project ATA 395, Lembang Horticultural Research Institute, Kotak Pos 428, Bandung 40001, Indonesia

Index