

## CHAPTER 7

### INTEGRATED PEST MANAGEMENT OF ONION IN SRI LANKA

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#### Abstract

Onion is one of the most important condiment crops grown in Sri Lanka. The onion crop is attacked by many pests at different crop growth stages causing considerable losses in yield. Thrips and onion caterpillars were identified as major pests and onion maggot and root eating ant as minor pests of the onion crop. Bulb mites, tuber moth and flower chafer beetles are new pests recently reported in Sri Lanka. The consistent use of insecticides to control the pests not only poses a severe threat to environment, human being and natural enemies but also build up resistance in pests. Therefore, integrated pest management practices were identified to manage the major pests. Research activities should be conducted to develop pest management strategies for the new pests reported in Sri Lanka. Biology and ecology of important pests associated with onion crop along with current management strategies based on chemical, biological, and cultural control as well as host plant resistance and future directions in onion pest management are summarized.

#### Introduction

Onion is one of the most important condiment crops grown in Sri Lanka. Two main types of onions, big onion (*Allium cepa*, variety cepa) and shallot or multiplier onion (*Allium cepa*, variety aggregatum) are cultivated in Sri Lanka. In 2013 the production of big onion and shallot were 69,638 t and 55,608 t, respectively. The annual cultivated extent of both types of onion was about 8,829 ha in 2013 (Agstat, 2014). It is generally used as a vegetable, spice or for medicinal purposes.

The onion is attacked by many pests at different growth stages causing considerable losses in yield (Table 1). In addition, these pests also reduce the

quality of bulbs after harvest, during processing and marketing. This paper reviews the important pests affecting onion along with their management practices and future research and development needs.

**Table 1: Pests of onion reported in Sri Lanka.**

<b>Major pests</b>
Thrips: <i>Thrips tabaci</i> Lindeman (Thysanoptera: Thripidae)
Onion caterpillars: <i>Spodoptera litura</i> (Fabricius), <i>S. exigua</i> (Hubner) (Lepidoptera: Noctuidae)
<b>Minor pests</b>
Onion maggot: <i>Delia antiqua</i> (Meiger) (Diptera: Anthomyiidae)
Root eating ant: <i>Dorylus orientalis</i> (Hymenoptera: Formicidae)
<b>New pests</b>
Bulb mite: <i>Rhizoglyphus</i> spp. (Acarina: Acaridae)
Tuber moth: <i>Phthorimaea operculella</i> (Lepidoptera: Gelechiidae)
Flower chafer beetle: <i>Oxycetonia versicolor</i> (Coleoptera: Scarabaeidae)

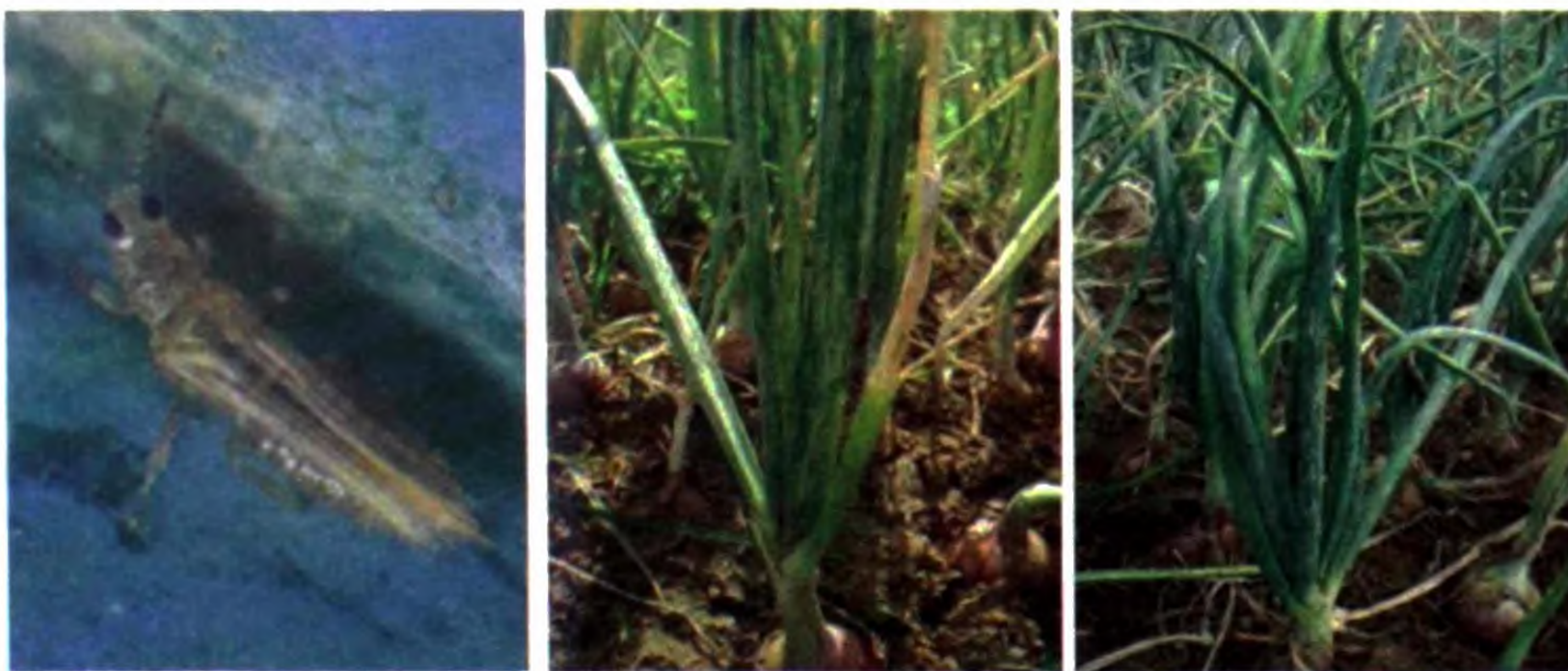
**Thrips: *Thrips tabaci* Lindeman (Thysanoptera: Thripidae)**

Onion thrip, is identified as a pest of national importance in Sri Lanka. It is the most common and serious insect pest of onion. High populations of thrips can reduce both yield and keeping quality of onions. The yield loss due to thrips damage has been estimated to be 20-40% (Anon, 2002).

Thrips are tiny slender insects, best seen with a hand lens or microscope. They are about 1.3 mm long (Plate 1). Adults have 2-pairs of wings that are fringed with long hairs. Thrips species vary in colour from pale yellow to light brown. Eggs are white to yellow, kidney-bean shaped, microscopic. Eggs hatch in 5-10 days. Larval instars I and II (0.5-1.0 mm) are active feeding stages. The immature stages

have the same general body shape as adults but are usually lighter in colour and wingless. They require 10-14 days to develop. The instars III (pre-pupa) and IV (pupa) (1.0-1.2 mm) are inactive, non-feeding stages. They are pale yellow to brown. They are found in the soil, at the base of the onion plant neck or underneath bulb scales. This stage lasts 5-10 days. Complete generation requires 2-4 weeks during warmer conditions. Five to eight generations may occur each year (Wijeratne, 2006).

Onion thrips have a wide host range, including cereals and broad leaved crops. They thrive in hot, dry conditions and are more damaging when these climatic conditions prevail for most of the production season. Thrips damage can initiate at any stage of the crop. Immature and adult thrips prefer to feed on newly emerged leaves at the centre of the onion neck. Both adult and larvae feed on foliage causing white to silver patches and streaks. When foliage is severely damaged, the entire field appears silvery (Plate 2). Thrips are most damaging when they feed during the early bulbing stage of plant development (Gunewardena *et al.*, 2013a).



**Plate 1: Adult thrip.**

**Plate 2: Thrips damaged plants.**

Population dynamics studies have shown that peak population of thrips occurs from July to August and associated with low relative humidity, high temperature and high wind velocity (Anon, 1991). Therefore, correct time of

planting (early May) is very important to minimize the damage. Use of recommended fertilizer at correct rate and time of application is very important. Onion crops should be fertilized with adequate, but not excessive amount of nitrogen fertilizer. In 2010 and 2011, goat manure, poultry manure and cow dung were tested against pests of onion and the low thrips incidence was observed in all the organic manure applied plots (Anon, 2011).

Mulches placed on plant beds (gliricidia leaves, neem leaves, paddy straw) have reduced thrips populations and improve onion growth. The thrips incidence was low in neem leaves treated plots (Anon, 2011). Selections of quality seeds, use of appropriate nursery management techniques, removal of plant residues after harvest were identified as other important practices to reduce the thrips population. Sticky traps can be used to reduce thrips by mass trapping them in the nursery or field. Sprinkler and drip irrigation can suppress thrips population levels (Gunewardena *et al.*, 2013a).

There is no known true resistance in onions to thrips. However, some onion varieties can tolerate thrips damage with a little yield loss. Varieties with tolerance to thrips require a few insecticide applications. Gunewardena *et al.* (2013a) evaluated 19 big onion lines along with the recommended variety, Dambulla Selection under insecticide free conditions. Thrips damage was low in the variety MIBO 1 (Anon, 2013). Varietal evaluation studies conducted at Thirunelvely in 2013 and 2014 revealed that all the shallot onion lines/varieties tested (Vethalam type - TVM 4, TVM 6, ARL 10, OHR, OH 8, True seeds, and small onion type - TVS 3, TVS 6, Jaffna Local and Thirunelvely Red) were susceptible to thrips (Anon, 2013a). Onion cultivars that have open neck growth and dark glossy leaves are less attractive to thrips. In 2008, exotic onion variety, Nashik Red was evaluated for pest incidences and found that it was severely damaged by thrips (Anon, 2008). Several species of predators (Anthocorid bugs, Pirate bugs *Orius* spp., Ground beetles, Lacewings, Spiders) that are associated with onion thrips have been identified (Anon, 1991).

Insecticides have been the primary approach for the management of thrips (Table 2). Farmers apply insecticides at weekly intervals to control thrips. In 1980's

organophosphate and carbamate group insecticides (Fenthion 50EC and Carbaryl 85% WP) were recommended for the control of thrips (Anon, 1982). The availability of series of new groups of insecticides and field reports indicated that the earlier recommended insecticides were not effective in controlling thrips. This necessitated the testing of new insecticides for the control of thrips in onion. In 2002, different insecticides were screened and Thiacloprid 24SC, Imidacloprid 20SC, Fipronil 5SC and Prothiofos 50EC were recommended against thrips (Anon, 2002).

**Table 2: Recommended and pipeline insecticides for control of onion thrips.**

Common name	Year of registration	Mode of action group	Estimated EIQ*values based on recommended dose		
			Consumer	Worker	Ecology
Fenthion 50EC	Prior to 1990	1B-AChE inhibitors	-	-	-
Carbaryl 85%WP	Prior to 1990	1A-AChE inhibitors	2.9	8.0	25.3
Thiacloprid 24SC	2002	4A-nAChR agonists	1.2	1.3	5.2
Imidacloprid 20SC	2002	4A-nAChR agonists	0.7	0.5	6.4
Fipronil 5SC	2002	2B- GABA– gated Chloride channel antagonists	0.2	1.0	3.3
Prothiofos 50EC	2002	1B-AChE inhibitors	-	-	-
Sulfoxaflor 24SC	Pipeline	4C- nAChR agonists	0.2	0.6	2.1
Pymetrozine 50%WG	Pipeline	9B-Selective homopteran feeding blockers	1.4	0.9	2.0

\*EIQ = Environmental Impact Quotient.

**Onion Caterpillars: *Spodoptera litura* (Fabricius), *S. exigua* (Hubner) (Lepidoptera: Noctuidae)**

*Spodoptera litura* adults are stout-bodied moths, 1.4-1.8 cm long and with a wingspan of about 3 cm. Forewings are dark-brown with distinctive grey-black markings. Hind wings are white with dark veins (Plate 3). Adult lifespan is 5 to 16

days. Eggs are almost spherical, slightly flattened, and about 0.5 mm in diameter. They are whitish yellow. Eggs hatch after 2 to 5 days, depending on temperature. Six larval instars occur. Newly hatched larvae are hairless and blackish-green with distinct band on the first abdominal segment. The mature larva is dull greyish and blackish green. Caterpillars have dark and light longitudinal bands and two dark, semi-circular spots on their back. Fully-grown caterpillars are about 40 mm in length (Plate 4). Larval stage of *S. litura* lasts 14 to 22 days. Mature caterpillars burrow into the soil to pupate. The pupae are brown and after pupation turning darker brown and finally almost black. They are 10 to 14 mm long. Pupal phase takes 7 to 15 days. The life cycle can be completed in about 5 weeks (Wijeratne, 2006).



**Plate 3: Adult of *Spodoptera litura*.**



**Plate 4: Larva of *Spodoptera***

*Spodoptera exigua* adult moths are moderately sized, the wing span measuring 25 to 30 mm. The forewings are mottled gray and brown and normally with an irregular banding pattern and a light coloured bean-shaped spot (Plate 5). The hind wings are a more uniform grey or white. Eggs are laid in clusters of 50 to 150 eggs/mass. Eggs are usually deposited on the lower surface of the leaf. Eggs hatch in 5-7 days. Larval period has six instars. The larvae are pale green or yellow (Plate 6). Mature larvae is about 37-50 cm. Larval development takes 10-12 days. Pupation occurs in the soil. The pupa is light brown and 15 to 20 mm in length. Duration of the pupal stage is 6-7 days during warm weather conditions (Wijeratne, 2006).

*Spodoptera litura* larvae bore into tubular leaves and feed concealed inside (Plate 7). Young larvae feed gregariously and skeletonize foliage. As they mature, larvae become solitary and make large irregular holes in foliage. *S. exigua* larvae feed on both foliage and bulbs (Gunewardena *et al.*, 2013a). In 1977, *S. exigua* outbreak was reported in Jaffna district and synthetic pyrethroids were recommended for the control. In 1979, light trap studies conducted at Thirunelvely showed that synthetic pyrethroids recommended for the control of onion caterpillar was not effective in reducing the damage (Anon, 1979). Therefore, different control measures were introduced to address the problem. Collection and destruction of egg masses and larvae, destruction of crop debris, flooding the field after harvesting, use of recommended fertilizers at correct rate and time of application were the recommended management practices for the control of onion caterpillars (Anon, 1979).

In 2006, onion caterpillar, (*S. exigua*) was reported as a serious pest in onion for the first time in the history in Matale district. Crop damage caused by this pest has been around 60-75%. In certain localities 100% crop loss has also been observed. Despite repeated application of recommended insecticides, including pyrethroids failed to provide an effective control of the pest. Therefore, new insecticides having different mode of action were tested and two insecticides, Metaflumizone 24 SC and Emamectin benzoate 5%SG were recommended (Table 3). Three applications of these insecticides in 7-10 day interval were sufficient to keep the damage below 10% (Gunewardena *et al.*, 2008).

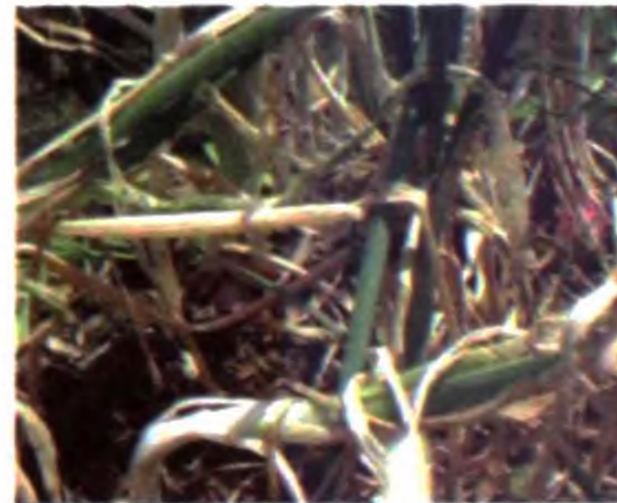
Very little attention has been paid in the past to biological control studies. In 1979, an attempt was made to investigate the possibilities of bio control of the *S. exigua*. A hymenopterous parasite, *Telenomus remus* was imported and tested at Thirunelvely. However, the parasite could not be recovered from the field (Anon, 1979). In 1984, nuclear polyhedrosis virus was used as bio control agent at Thirunelvely (Anon, 1984). In addition, different predators such as ants, pirate bugs, lacewing and lady bird beetles were identified to be associated with onion caterpillars (Anon, 1991).



**Plate 5: Adult of *Spodoptera exigua***



**Plate 6: Mature larvae of *Spodoptera exigua***



**Plate 7: Onion caterpillar damaged leaves**

### **Onion Maggot: *Delia antiqua* (Meiger) (Diptera: Anthromyiidae)**

Onion maggot is a minor pest of onion. Adults are slender, grey, large-winged, 6 mm long and resemble houseflies. It has large legs and narrower abdomen (Plate 8). Eggs hatch into maggots 2-3 days after being laid. There are three cream-coloured larval stages. The full grown maggot larvae is pearly white, 8mm long and legless (Plate 9). Larval stages complete within 2-4 weeks depending on the temperature. The pupa is chestnut brown and 8mm long. First and second generation pupae remain in soil for 2-4 weeks before adult emergence. Cool, wet weather favours the development of onion maggots, while hot, dry weather is detrimental to the survival of this pest.

Onion maggot larvae feed on the below-ground tissues of seedlings (Plate 10). The damage done at first larval stage is more severe as this occurs when the plants are young. The larvae can kill small seedlings, which first wilt and then

become flaccid. Therefore, poor plant stands may indicate an onion maggot attack. Later generations may infest developing bulbs resulting in distorted growth accompanied by rotting tissue. Culled onions left piled on the ground are an important source of insect infestation. In addition, feeding and burrowing by the maggot may introduce and spread fungal and bacterial pathogens. Destruction of crop debris and removal of culls from the field is extremely important in controlling the onion maggot.

**Table 3: Recommended insecticides for onion caterpillars.**

Common name	Year of registration	Mode of action group	Estimated EIQ values based on recommended dose		
			Consumer	Worker	Ecology
Carbofuran 3% G	1979	1A-AChE inhibitors	9.1	32.1	40.1
Deltamethrin 2.5EC	1979	3A-Sodium channel modulators	0.0	0.1	0.4
Esfenvalerate 7.5EC	1979	3A-Sodium channel modulators	0.0	0.1	0.9
Cyfluthrin5E C	1979	3A-Sodium channel modulators	0.1	0.1	2.3
Permethrin 25EC	1979	3A-Sodium channel modulators	0.1	0.3	1.9
Fenvalerate 20EC	1979	3A-Sodium channel modulators	0.2	0.5	7.4
Diazinon 50 EC	1982	1B-AChE inhibitors	2.1	5.9	10.5
Chlorfluazuro n5EC	1982	15- Growth regulators	0.1	0.3	1.4
Metaflumizon e 24SC	2008	22B-Voltage dependent sodium channel blockers	0.6	1.3	8.2
Emamectin benzoate 5SG	2008	6- Chloride channel activators	0.0	0.1	0.5



**Plate 8: Adult of onion maggot**



**Plate 9: Larvae of maggots**



**Figure 10: Maggot damaged onion bulbs.**

### **Root Eating Ants: *Dorylus orientalis* (Hymenoptera: Formicidae)**

Adults are reddish brown ants. Head is nearly rectangular with a flat posterior margin (Plate 11). They live as colonies. At the early stage of the plant growth, ants damage roots and underground parts of the onion plants. They make burrows in soil. Under dry weather conditions, red ants cause considerable damage to onion roots (Dharmasena, 1993). Before establishing the crop, exposing soil to direct sunlight and destroying crop debris will help to reduce the population of ants. When a crop is damaged by ants, Diazinon 50EC can be applied to soil to reduce the ant damage (Anon, 2009).

### **Bulb Mite: *Rhizoglyphus* spp. (Acarina: Acaridae)**

Bulb mite is a new pest reported in onion crop. They are 0.5-1mm long and shiny creamy white. Adults have four pairs of legs (Plate 12). They can infest bulbs in storage or in the field. Bulb mites can survive on decaying vegetation in the field until complete decomposition. Mites can be seen only under microscope (Gunewardena *et al.*, 2013b). Bulb mites attack roots and basal plate of onion plants. They reduce plant stands, make stunted plant growth and promote bulb rot during storage (Plates 13 and 14). The damage caused by bulb mites to the outer tissues helps the rotting organisms (fungi, bacteria) to penetrate into the bulbs (Plate 15). Crop rotation, soaking bulbs in miticides before planting, fallowing of fields, flood irrigation and use of mites free bulbs for planting help to reduce mite infestation (Gunewardena *et al.*, 2013b).

**Tuber Moth: *Phthorimaea operculella* (Lepidoptera: Gelechiidae)**

Tuber moth was identified as a new pest of onion. The wing span is 10-12 mm. Fore wings are yellowish grey sprinkled with little black spots and the hind wings are grey (Plate 16). Eggs are oval, smooth and milky white. Larva is 10-12 mm long. It is rosy white with brown-black head. Pupa is narrow, 12 mm long and whitish. Larvae damage onion bulbs during storage (Plate 17). The damaged bulbs can be infected with fungi and bacteria and become rotten (Gunewardena *et al.*, 2013b). Destruction of infested bulbs is an important preventive method (Anon, 1990). Nugaliyadda *et al.* (2014) developed pheromone based method for the management of tuber moth. The yellow delta traps containing phero-lure found to be effective in attracting male moths.

**Flower Chafer Beetle: *Oxycetonia versicolor* (Coleoptera: Scarabaeidae)**

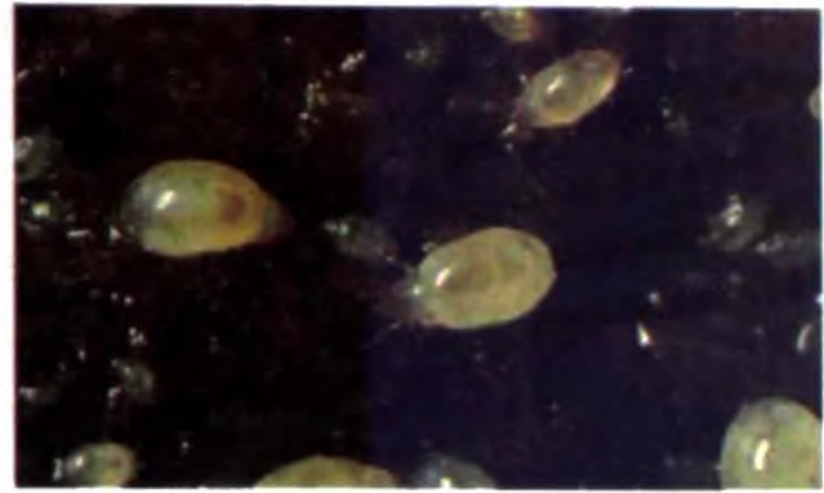
Flower chafer beetle is a new pest. It is brown with white markings on the elytra. Beetle is about 1 cm long (Plate 18). It damages onion flowers. Heavy infestation of flower beetles may cause considerable damage to onion crops. Hand picking of beetles can be done to control the problem (Gunewardena *et al.*, 2013b).

**Future Directions for Onion Pest Management**

Pests are considered as one of the main constraints to increase the productivity of onion. Pesticides are used as the first line of defence by farmers for managing the pests. Recognizing the drawbacks associated with chemical pesticides, such as environmental pollution, human health hazards, pests becoming resistant to pesticides, secondary pest outbreaks etc., it is important to develop integrated pest management strategies to control onion pests. Research efforts should be undertaken to investigate the potential for biological control methods, especially for onion caterpillars. Information on the natural enemies available should be collected. Pheromones based control methods should be developed. Effect of secondary plants on onion pest management should be studied. Strong monitoring strategies should be designed to identify major pests.



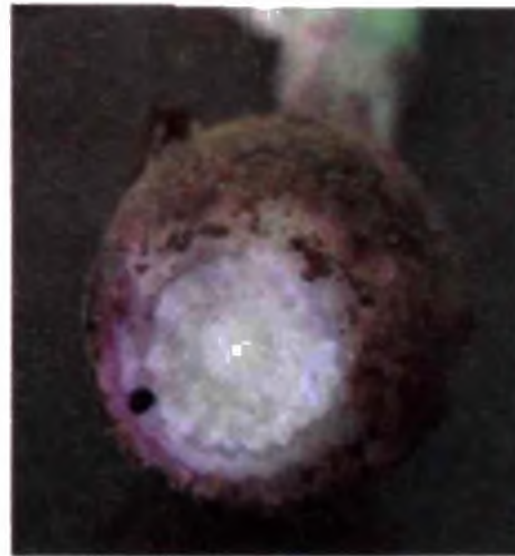
**Plate 11: Root eating ant**



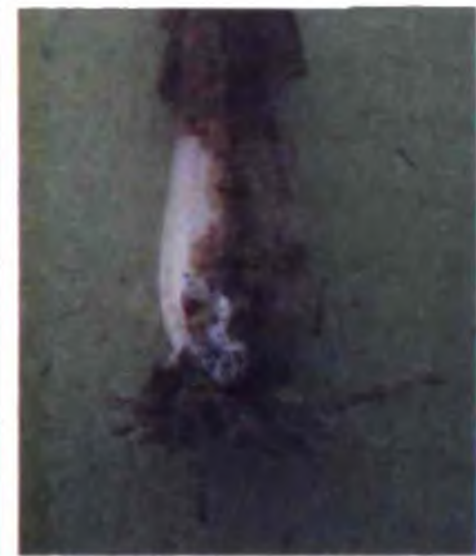
**Plate 12: Adult bulb mites**



**Plate 13: Bulb mite damage**



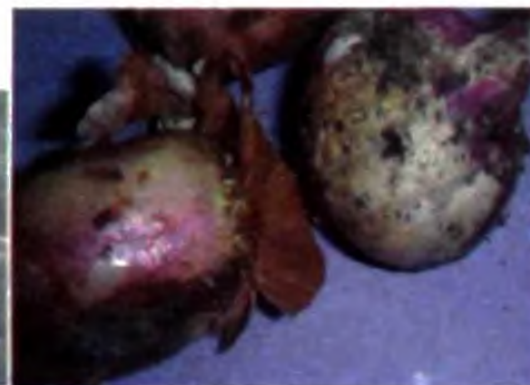
**Plate 14: Bulb mite damaged bulbs**



**Plate 15: Secondary damage by fungi**



**Plate 16: Adult of tuber moth**



**Plate 17: Tuber moth damaged bulbs**



**Plate 18: Adult flowerchafer beetle**

In addition, more emphasis should be given to develop better pesticide application technology especially for thrips control as the insecticides hardly reach the target pests living at the base of plants. Economic thresholds, at which insecticides are needed, should be identified. The impact of recommended

insecticides for pest resistance especially, for thrips should be determined. Farmers should be educated and trained to build up their knowledge and skills on pest management. Group approach through farmer training classes, demonstrations, field days as well as mass media is useful in disseminating this information.

### **Conclusions and Recommendations**

Pest problems in onion cultivation in Sri Lanka have been identified and recorded. Identified methods for the management of these pests should be documented for farmer adoption. Biology, ecology and behaviour of the pests should be studied to develop better understanding of pests and threshold levels for control. Priority should be given to identify biological control agents of major pests, and plant resistance to widen management options. A need has arisen to develop improved pesticide application/delivery system to enhance the effectiveness and efficiency of pesticides in controlling pests and to minimize the pesticide loading to the environment through drifts and other means.

There is a need to continually update the recommended management methods utilizing information generated. Demonstration plots/fields should be established to educate farmers on the best pest and crop management practices at village level and also to monitor pest infestation levels. This is in view of increasing trends for onion production in the country and enormous economic benefits that farmers could obtain from the crop.

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