PEST RISK ANALYSIS (PRA) TRAINING

Group Exercises Manual

Standards and Trade Development Facility

Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments

Table of Contents

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FOREWORD

Welcome to the IPPC introductory pest risk analysis (PRA) group exercise manual. This manual has been designed to provide practical guidance to biological scientists, plant pest risk assessors, plant pest risk analysts and phytosanitary policy makers working in the field of international phytosanitary affairs who want a basic introduction to PRA.

The exercises in this manual were designed to complement the classroom lectures given in the introduction to PRA course. These exercises are meant to be interactive and to provide participants with the chance to put into practice the skills and theory being taught in the lectures. By working through these group exercises, participants will gain experience in conducting PRAs and will understand the purpose of PRA and how PRA fits into the IPPC.

Upon completion of this course participants should be familiar with the structure and function of a PRA document and have conducted a number of trial PRAs as well as seen and discussed examples of many more. They should have the self confidence to complete PRAs and will know where to look for information to assist them and where to seek help when required.

NOTE: All exercises in this manual have been developed solely for the purpose of this course and are hypothetical. They do not reflect any real country, situation, commodity or pest.

GROUP EXERCISE NO. 1 - TERMINOLOGY

The purpose of this exercise is to acquire familiarity and understanding of phytosanitary terms and definitions which are used in ISPMs and for official phytosanitary purposes, in phytosanitary legislation and regulations and information exchange between NPPOs.

Description of exercise

Each participant will be provided with a unique, numbered definition that corresponds to one of the terms listed in the following Terminology Matching Table. The goal is to match the definitions on the participants' cards with the corresponding IPPC terms listed in the table.

The table can only be completed by talking to the other participants to find out what definition they were given, gradually filling in the blanks while circulating through the group and exchanging information. The third column in the table with the heading "Participant's name" is to be filled by adding the name of each person you have talked to beside the definition they provided you with.

Important remarks

1. A total of 30 cards with a single definition will be distributed. The instructors will each have one, so they will need to be consulted as well.
2. There are 30 blank spaces in the table to fill in.
3. Each definition is numbered. Participants should write the number from the cards into their table next to the appropriate term, they do not need to write out the entire definition.
4. The exercise is not a competition to see who will complete the table first. Students are to fill in as many blanks as they can in the time allotted, but should take the time to read the definitions of others and agree together on the selection of the corresponding term.

Terminology Matching Table

TERM	DEFINITION NUMBER	PARTICIPANT'S NAME
Endangered area		
Introduction		
Pest free place of production		
Plant products		
Official control		
Pathway		
Entry (of a consignment)		
Pest risk management		
Pest categorisation		
Habitat		
Area of low pest prevalence		
Monitoring		
Regulated article		
Pest risk analysis		
Entry (of a pest)		
Pest free production site		
ISPM		
Pest		
PRA area		
Consignment		
Pest risk assessment		
Pest free area		
Host range		
Organism		
Regulated non-quarantine pest		
Establishment		
Commodity		
Quarantine pest		
Phytosanitary measure		
Transparency		

GROUP EXERCISE NO. 2 - CATEGORISATION

At the outset, it may not be clear which pest(s) identified in Stage 1 (Initiation) may be candidates for a PRA. The categorisation process examines for each pest whether the criteria in the definition for a quarantine pest are satisfied.

<u>Part 1</u> (15 minutes)
Look at the definition of a quarantine pest and other related definitions. What information do you need? Make a list of the necessary data.

Quarantine pest: "A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled." (ISPM No. 5: *Glossary of Phytosanitary Terms*)

Elements of categorisation

List of necessary data

<u>Part 2</u> (60 minutes)
Scenarios and datasheets for several organisms are provided (Examples 1-8). For each example, identify the initiation point and the PRA area. Then, answer the following questions to determine whether each organism meets the definition of a quarantine pest.

1. Identity of Pest

- Is the organism clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?
- If the causal agent of particular symptoms has not yet been fully identified, has it been shown to produce consistent symptoms and to be transmissible?

Pest Identity	
Pest Type	

If the answer is no, the PRA process may stop. Possibly, further research is necessary to go on with the PRA.

2. Presence or absence in PRA area

- Does the pest occur in the PRA area?
- If so, is the pest widely distributed in the PRA area?

Present in PRA Area?	Yes [__] No [__] Comment:
Widely distributed in PRA Area?	Yes [__] No [__] Comment:
Important Assumptions	

If the pest is present and widely distributed in the PRA area, the PRA may stop (remember the definition of a quarantine pest). If the pest is present in the PRA area, but not widely distributed there, it should be under official control or expected to be under official control in the near future (see Question 3). If the pest is absent from the PRA area, continue with Question 4.

3. Regulatory status

Regulated in PRA Area?	Yes [__] No [__] Comment:
Important Assumptions	

If the pest is present in the PRA area and not under official control, the PRA may stop.

4. Potential for establishment and spread in the PRA area

- Does the known area of current distribution of the pest include ecoclimatic conditions comparable with those of the PRA area or sufficiently similar for the pest to survive and thrive (consider also protected conditions)?
- Does at least one host-plant species (for pests directly affecting plants) or one suitable habitat (for non parasitic plants) occur in the PRA area (outdoors, in protected cultivation or both)?
- If a vector is the only means by which the pest can spread, is a vector present in the PRA area?

Potential to establish and spread?	Yes [__] No [__] Comment:
Important Assumptions	

If the answer is no, the PRA may stop. If yes, go to Question 5.

5. Potential for economic consequences in PRA area

- Is the organism in its area of current distribution a known pest of plants or plant products?
- Does the organism have intrinsic attributes that indicate that it could cause significant harm to plants? (Some organisms may not be known to be harmful in their area of current distribution, but may nevertheless have the potential to become pests in the PRA area. This possibility may have to be considered in certain circumstances).
- Could the pest by itself, or acting as a vector, cause significant damage or loss to plants or other negative economic impacts (on the environment, on society, on export markets) through the effect on plant health in the PRA area?

Potential for economic consequences?	Yes [__] No [__] Comment:
Important Assumptions	

If the answer is no, the PRA may stop.

6. Conclusion of pest categorisation

- Does this organism qualify as a quarantine pest for the PRA area? Summarize the main elements leading to your conclusion.

Quarantine pest?	Yes [__] No [__] Comment:
Important Assumptions	

If it has been determined that the pest has the potential to be a quarantine pest, the PRA process should continue. If a pest does not fulfil all of the criteria for a quarantine pest, the PRA process for that pest may stop. In the absence of sufficient information, the uncertainties should be identified and the PRA process should continue.

Part 3 (30 minutes)

In the case of a PRA initiated by a pathway, there may be a number of pests that need to be categorized. It may be useful to summarize this information in a table. Using the examples from Part 2, develop a table to summarize your results.

Example No. 1 – Butternut Canker[1]

SCENARIO: Several European countries have received requests to import nursery stock plants of walnut (*Juglans* spp.) from North America. At their request, the European and Mediterranean Plant Protection Organization (EPPO) has agreed to conduct a PRA. One of the primary pests of concern is the butternut canker (*Sirococcus clavigignenti-juglandacearum*).

PEST DATASHEET:
Identity: *Sirococcus clavigignenti-juglandacearum* Nair, Kostichka and Kuntz (Fungi: Ascomycota (anamorphic)). The form-genus *Sirococcus* is probably heterogeneous and the affinities of this fungus are not clear. Common name: Butternut canker.

Hosts: In North America *Juglans cinerea* (butternut) is the only species that is killed by the pathogen, though other *Juglans* species and hybrids (e.g. *J. ailantifolia* var. *cordiformis*, *J. regia* and *J. nigra*) are diseased to varying degrees. More data is needed on the susceptibility of these species. In Europe, *J. regia* is widely planted for its nuts, oil and valuable wood except in the north, as it needs mild winters without late frosts, and a climate which is not too dry. *J. nigra* is also cultivated in Europe and used as rootstocks for *J. regia* or as an amenity tree, and sold in nurseries. Laboratory experiments indicated that *S. clavigignenti-juglandacearum* might be able to survive on other Juglandaceous hosts (*Carya* spp.) and possibly other trees (*Quercus*, *Prunus*).

Distribution: Origin: Possibly Asia or South America. Present: North America (Canada - Quebec, Ontario, New Brunswick; USA - north-eastern states). Absent: EPPO region.

Biology and Dispersal: Conidia develop beneath infected bark in sticky masses. Stromatal pegs lift and rupture the bark and, under moist conditions, millions of conidia are extruded. These conidia are dispersed by rain splash and wind in little droplets or as aerosols during rainfall. They are transported by run-off water from infected branches to tree trunks, infecting buds, wounds and other openings. Infection results in multiple stem cankers. Cankers on twigs start to develop, usually in the lower crown. Spores require at least 16 h of dew at 20°C to germinate on the bark of *J. cinerea*. In infected suckers, twigs and branches, cell walls of the bark are degraded, macerated and rapidly broken up entirely. The fungal hyphae penetrate the phloem, then the xylem, and progress finally into other bark and wood tissues. They create new cankers when reaching the cambium. The fungus is able to sporulate on standing or felled dead trees for at least 20 months. Outside the host, conidia can survive for at least 8 h in cool and cloudy weather. The pathogen remains viable in diseased tissue and in culture down to 0°C and below. Dispersal occurs by wind and rain (spores, conidia), and insects probably also play a role in disease dissemination as vectors or wounding agents. The fungus may be seed-borne, at least in seeds of *J. cinerea* and *J. nigra*. Movement of scion wood and other propagative material, as well as untreated logs and firewood with bark, may contribute to dispersal of the fungus.

Damage: *S. clavigignenti-juglandacearum* is a very aggressive pest that causes cankers on stems, branches and exposed roots. As cankers coalesce progressively, they girdle branches and stems which may lead to tree death. The fungus has caused dramatic declines of *J. cinerea* in the USA (in some states, up to 80%). Good quality wood of *J. cinerea* is valuable for woodworking, furniture, cabinetry and dye production. Nuts are an important source of food for wildlife, and the decline of *J. cinerea* in North American forests is perceived as a threat to biodiversity. In central Europe, *J. regia* and *J. nigra* have the most valuable wood and high-quality veneers make profits of more than 5000 EUR per m^3. Wood of *J. regia* is used for cabinetry, musical instruments, crafts and stocks, and nut and oil production are also important industries in southern Europe.

Control: There is no known effective control against butternut canker, other than the removal of recently killed and visibly infected trees to locally reduce the amount of inoculum, or the selection and propagation of resistant trees.

[1] **NOTE:** This example was developed specifically for use in the IPPC PRA training course. The scenario is not real. The data sheet is based on the EPPO Alert List 2005 and EPPO Data Sheet 2006, URL: http://www.eppo.org/.

Example No. 2 – Vegetable Weevil[2]

SCENARIO: Several countries in northern Africa (Morocco, Algeria, Tunisia, Libya, Egypt) have received requests to import ware potato tubers from South Africa. At their request, the InterAfrican Phytosanitary Council has agreed to compile a list of potato pests in South Africa. The vegetable weevil (*Listroderes costirostris*) is on the list.

PEST DATASHEET:
Identity: *Listroderes costirostris* Schönherr (Insecta: Coleoptera: Curculionidae). Synonym: *Listroderes obliquus* Klug. Common name: Vegetable weevil.

Hosts: *L. costirostris* is polyphagous. Crop hosts include *Allium cepa* (onion), *Arachis hypogaea* (groundnut), *Beta vulgaris* (beetroot), *Brassica napus* (rape), *Capsicum annuum* (pepper), *Daucus carota* (carrot), *Lactuca sativa* (lettuce), *Lycopersicon esculentum* (tomato), *Nicotiana tabacum* (tobacco), *Pastinaca sativa* (parsnip), *Petroselinum crispum* (parsley), *Solanum tuberosum* (potato), *Spinacia oleracea* (spinach) and *Solanum melongena* (aubergine). Wild hosts include *Cirsium* spp., *Eupatorium, Linaria* (toadflax), *Malva* (mallow), *Oxalis* (wood sorrels), *Plantago* (plantain), *Rumex* (dock), *Sonchus* (sowthistle), *Stellaria media* (common chickweed).

Distribution: Origin: *L. costirostris* is native to South America. Present: North America (USA; many states from California to Florida and up the east coast to New Jersey; also Hawaii). South America (many countries); Europe (Portugal, Spain), Africa (Morocco, South Africa); Asia (China (Taiwan), Japan, Korea); Oceania (Australia (Northern Territory, New South Wales, Queensland, South Australia), New Zealand). Absent: Much of Europe, much of Africa, much of Asia.

Biology and Dispersal: *L. costirostris* deposits its eggs on the leaves and stems of plants or in nearby soil. The eggs are usually deposited singly, but sometimes two to eight or more are deposited. In the southern USA eggs are laid from September until the end of April, but this varies according to temperature. At 13°C eggs hatch in approximately 33 days but at 24°C they hatch in 15 days. After hatching, larvae feed on the buds or the undersides of leaves. Later they feed on all the foliage. They can also feed on the roots of root crops causing severe damage. The larval period varies greatly according to temperature and moisture, averaging approximately 35 days. The pupae are found in the soil at depths of 12 to 50 mm. The pupal period ranges from 13 to 41 days. Pupae are present in the field from mid-November until the middle of June. Peak adult emergence occurs in January. The newly-emerged weevils are voracious feeders and seek food immediately after emergence. In the summer months the adults usually become inactive, except for occasional periods of slight feeding activity. They usually feed on the foliage of their host plants, but under some circumstances they feed on the roots of vegetables. Feeding occurs principally during the night. During the day, weevils hide under leaves, clods of earth, or other objects close to the soil surface. As temperatures rise early in the summer, the adults aestivate. After temperatures fall at the end of the summer, the adults leave shelter resume their feeding activities. The adults occur in the field throughout the year, but are present in greatest abundance from the end of December until mid-April. *L. costirostris* may be disseminated by natural and artificial means. In the southern USA it has spread at approximately 50 miles per year. Spread has been fastest in open, cultivated areas and slowest in wooded regions. Field observations suggest that flight may be the principal means of dispersal. Adults crawl rather slowly.

Damage: *L. costirostris* is a polyphagous pest, primarily affecting vegetables, but can also feed on flowers and many wild hosts. In Western Australia, potatoes, tomatoes and root crops are the preferred food plants. In northern Africa (Morocco, Algeria, Tunisia, Libya, Egypt), potato production alone amounted to just over 6.3 million tonnes in 2004, with an export value of almost $100 million USD.

Control: Approved insecticides are effective. Natural enemies from South America have been released in Australia but none of them established self-sustaining populations.

[2] **NOTE:** This example was developed specifically for use in the IPPC PRA training course. The scenario is not real. The data sheet is based on the CABI Crop Protection Compendium URL: http://www.cabi.org/compendia/cpc, with additional production data from the FAO statistics database URL: http://faostat.fao.org/.

Example No. 3 – Water Hyacinth[3]

SCENARIO: Nepal has received requests to import nursery stock plants of water hyacinth (*Eichhornia crassipes*) for use in water gardens. The NPPO has decided to conduct a PRA.

PEST DATASHEET:
Identity: *Eichhornia crassipes* (Mart.) Solms (Liliopsida (monocotyledons): Liliales: Pontederiaceae). Synonym: *Pontederia crassipes* Mart. (basionym). Common name: Water hyacinth.

Habitat / Hosts: *E. crassipes* is a floating weed of tropical and sub-tropical freshwater lakes and rivers, especially those enriched with plant nutrients. It may also be a weed in flooded rice. Optimum temperature for growth is 25-30°C. Growth ceases when water temperature is above 40°C or below 10°C, but short periods at freezing may be tolerated. *E. crassipes* is very responsive to nutrients (especially nitrogen and phosphorus) and high growth rates are always associated with eutrophic, nutrient-rich conditions. Optimum pH is between 6 and 8 and extremes of pH (below 4.5 or above 10) can be damaging. Calcium concentration is important, with an observed threshold of 5 mg/l, below which growth ceases.

Distribution: Origin: Amazon basin of Brazil. Present: Much of South America, Central America and the Caribbean; Mexico; the United States (Alabama, Arkansas, California, Florida, Georgia, Hawaii, Louisiana, Mississippi, North Carolina, South Carolina, Texas); Europe (Czech Republic, France, Portugal); much of Africa; Pakistan; India; Southeast Asia; Korea; Japan; China (Fujian, Guangdong, Hong Kong, Jiangsu, Taiwan, Yunnan, Zhejiang); Australia; New Zealand. Absent: Canada; northern Eurasia; Nepal.

Biology and Dispersal: *E. crassipes* propagates vegetatively and by seed. After flowering, the capsules mature and seeds are eventually released below water. The seeds are capable of germinating immediately but may remain dormant for many years. Germination is encouraged by aerobic conditions and alternating temperatures. Large populations of seedlings may become established on exposed mud at the edges of water bodies when water levels fall. Seedlings are rooted in mud initially but become free-floating as a result of wave action or rising water levels. From an early stage, the axillary buds of the older leaves of the seedling are capable of developing into stolons, which grow horizontally and develop daughter plants. Such vegetative spread can occur indefinitely and very large populations are produced in this way without any sexual reproduction. Wind will readily move the plant and the upright leaves act as sails in lakes and canals. Along rivers, water flow is the prime mover of vegetative material but strong winds may sometimes blow the plant upstream. Seeds are thought to be transported over long distances by water birds. New infestations may arise via unintentional human transportation such as canoes and boats. However, the primary means of long-distance dispersal is the deliberate introduction of plants for use in water gardens.

Damage: *E. crassipes* is considered the world's most troublesome aquatic plant, and is a major freshwater weed in most regions of the world that are free of frost. It has been widely distributed for ornamental purposes since the 1800s, and has escaped cultivation and spread with phenomenal rapidity wherever it has encountered suitable environmental conditions. It forms vast monotypic stands in lakes, rivers and rice paddy fields, reducing water quality and encouraging the growth of mosquitoes, snails and other organisms associated with human illnesses (e.g. malaria, schistosomiasis, encephalitis, filariasis and cholera). Dense mats greatly hinder boating by fishermen and may prevent fishing altogether. In paddy fields, dense mats affect rice production and in extreme cases of competition between *E. crassipes* and rice crops, fields have been abandoned.

Control: It is impossible to eradicate *E. crassipes*, and often only an integrated management strategy, inclusive of chemical and biological control, can provide a long-term solution to this pest.

[3] **NOTE:** This example was developed specifically for use in the IPPC PRA training course. The scenario is not real. The data sheet is based on the CABI Crop Protection Compendium (http://www.cabi.org/compendia/cpc).

Example No. 4 – Sudden Oak Death or Ramorum Blight and Dieback[4]

SCENARIO: New Zealand has been importing rose plants (*Rosa* species) from California for many years. Recently a new high profile disease caused by *Phytophthora ramorum*, has been recorded on species within the genus *Rosa* in Californian nurseries. The nursery industry in New Zealand has asked Biosecurity New Zealand to review of the risks of importing rose plants from areas potentially contaminated by *P. ramorum*.

PEST DATASHEET:
Identity: *Phytophthora ramorum* Werres, De Cock and Man in't Veld (Straminipila, Stramenophila or Chromista: Oomycota: Peronosporales). Common name: Sudden oak death (on oaks) and Ramorum blight and dieback (on other hosts).

Hosts: *Arbutus menziesii* (Pacific madrone), *Heteromeles salicifolia* (toyon), *Lithocarpus densiflorus* (tanoak), *Pseudotsuga menziesii* (Douglas-fir), *Quercus* spp., including *agrifolia*, *chrysolepis* and others (oaks and live oaks), *Acer macrophyllum* (broadleaf maple), *Aesculus californica* (California buckeye), *Camellia*, *Corylus cornuta* (beaked hazel), *Lonicera hispidula*, *Rhamnus purshiana* (cascara buckthorn), *Rhododendron* (azalea), *Rosa gymnocarpa* (wood rose), *Sambucus nigra* (elder), *Sequoia sempervirens* (coast redwood), *Taxus baccata* (English yew), *Umbellularia californica* (California laurel), *Viburnum bodnantense*, *Vaccinium* (blueberries). Experimental hosts (in *Rosa*) include: *Rosa californica* (California rose), *Rosa canina* (rog rose), *Rosa odorata* (tea rose), *Rosa sempervirens* (evergreen rose), *Rosa setigera* (climbing rose).

Distribution: Origin: Unknown. Present: USA (detected in nursery stock in many states from California to Florida and up the east coast to Washington; present in wildlands in CA and OR only); Canada (few occurrences in British Columbia); Europe (many countries). Absent: Not recorded in New Zealand, Australia, South America, Asia, and Africa.

Biology and Dispersal: The coastal distribution of *P. ramorum* in California suggests that the pathogen is favoured by moist and moderate climates. In the absence of free water, plant infection is significantly reduced as zoospores are the main source of infection. *P. ramorum* is a polycyclic pathogen and evidence on the distribution and spread of sudden oak death has led to the conclusion that a number of means of dispersal may be possible. In addition to oospores, the fungus-like organism can produce chlamydospores, sporangia, hyphae and motile zoospores, all of which could serve as dispersal structures under the right circumstances. Oospores of *P. ramorum* have not been observed in nature. Like chlamydospores, oospores are important for surviving unfavourable environmental conditions. Sporangia and zoospores are transported short distances via rain or wind. In nurseries, they can also be moved within the irrigation water system. Sporangia or zoospores have been shown to initiate infections in susceptible trees. In nature, sporangia release zoospores but sporangia can also behave like spores and infect plants. Longer dispersal distances may be achieved through movement of diseased plant material and infested soils, by transport of spores in water streams or during storms. *P. ramorum* can easily survive 6 months in infected leaves buried in soil.

Damage: *P. ramorum* can infect numerous plant species, and has caused the death of several broadleaf tree species in California, including *Lithocarpus densiflorus* and several *Quercus* species. Many of the susceptible northern hemisphere species are also important members of urban or commercial forests in New Zealand.

Control: No chemical treatments are available to eliminate the disease in infected plant material. Aerated steam maintained at 50 °C for 30 minutes is effective but it kills the plant material as well. Certification programs have been developed to limit the presence of the pathogen in nursery stock; *Phytophthora ramorum* is under official control in CA, WA and OR (USA) and Canada.

[4] **NOTE:** This example was developed specifically for use in the IPPC PRA training course. The scenario is not real and facts have been simplified or omitted. The data sheet is based on the Canadian PRA for *Phytophthora ramorum* (CFIA 2006) and the CABI Crop Protection Compendium URL: http://www.cabi.org/compendia/cpc.

Example No. 5 – Pepper Fruit Fly[5]

SCENARIO: Chile has received a request to import melon (*Cucurbita melo*) fresh fruit from several Caribbean countries. The plant health authority (Servicio Agrícola y Ganadero) has initiated a PRA and has begun compiling a list of melon pests in Caribbean countries. The pepper fruit fly (*Atherigona orientalis*) is on the list.

PEST DATASHEET:
Identity: *Atherigona orientalis* Schiner (Insecta: Diptera: Muscidae). Synonyms: *Acritochaeta excisa*; *Acritochaeta orientalis* (Schiner); *Atherigona excisa* var *flavipennis* Malloch; *Coenosia excisa* Thomson; *Atherigona magnipalpis* Stein; *Atherigona trillineata* Stein; *Acritohaeta pulvinata* Grimshaw. Common names: Pepper fruit fly; tomato fly.

Hosts: *A. orientalis* is typically found in damaged plant material, including fruits, and it may also develop in dung and dead insects. It is unclear whether the pest causes the plant damage (phytophagous) or whether it simply enters already damaged plant material and acts as a saprophagous species. Major hosts reported are: *Brassica oleracea* (cabbages, cauliflowers), *Capsicum annuum* (bell pepper), *Citrus sinensis* (navel orange), *Cucumis melo* (melon), *Lycopersicon esculentum* (tomato), *Phaseolus* (beans), *Sorghum bicolor* (sorghum). Minor hosts include: *Allium cepa* (onion), *Benincasa hispida* (wax gourd), *Capsicum frutescens* (chilli), *Carica papaya* (papaw), *Citrullus*, *Citrus*, *Cocos nucifera* (coconut), *Cucumis sativus* (cucumber), *Cucurbita pepo* (ornamental gourd), *Daucus carota* (carrot), *Echinochloa colona* (junglerice), *Ficus*, *Glycine max* (soyabean), *Helianthus annuus* (sunflower), *Luffa acutangula* (angled luffa), *Mangifera indica* (mango), *Manihot esculenta* (cassava), *Momordica spp.*, *Musa x paradisiaca* (plantain), *Oryza sativa* (rice), *Pennisetum glaucum* (pearl millet), *Prunus persica* (peach), *Solanum melongena* (aubergine), *Spondias mombin* (hog plum), *Triticum aestivum* (wheat), *Zea mays* (maize), *Zingiber officinale* (ginger).

Distribution: The pest has a pantropical distribution and does not occur in temperate areas. Present: Widely distributed in Africa, Asia, and Oceania; present in Europe (Cyprus, Spain); present in South America (Argentina, Brazil, Chile (Easter Island, unconfirmed), Colombia, Ecuador, Guyana, Paraguay, Peru, Venezuela); much of Central America; North America (Mexico, southern USA).

Biology and Dispersal: Under laboratory conditions at a mean temperature of 28°C and 63% RH, the egg stage, first-, second- and third-instar larva, and pupariation took 1, 0.5-1, 1-2, 9-11 and 12-15 days, respectively. In Pakistan, six to seven generations were passed during the crop season and the average incubation, larval and puparial periods ranged from 36 to 48 hours, 7 to 8 days and 5 to 6 days, respectively; 15-19 eggs being laid under the skin of each Capsicum fruit. The larvae penetrate Capsicum fruits of all ages and feed on the ovules, seeds, placenta and mesocarp, making them susceptible to secondary infection by rot-producing microorganisms. Plant parts likely to carry the pest in trade / transport include fruits and pods (larvae; borne internally; visible under light microscope), leaves (eggs, larvae; borne internally; visible to naked eye), stems, shoots, and other above-ground plant parts such as trunks and branches (eggs, larvae; borne internally; visible under light microscope).

Damage: *A. orientalis* is very widespread and probably already established in most climatically suitable areas. However, it is regarded as a serious quarantine threat to New Zealand who restrict the importation of cucurbits from Australia. In Pakistan, 25-85% infestation of melon fruits has been reported, and in India, tomato, pepper, wheat, and corn have been attacked. Although primarily a saprophage, it is of some importance as a major vector of faecal and other filth-borne diseases.

Control: Treatments normally applied for the control of stem-borers may be used, for example, granules of systemic insecticide may be applied at drilling. Use of chemical fertilizers instead of manure may also help, as chicken dung has been shown to attract the flies.

[5] **NOTE:** This example was developed specifically for use in the IPPC PRA training course. The scenario is not real. The data sheet is based on the OIRSA data sheet URL http://www.oirsa.org/ and the CABI Crop Protection Compendium URL: http://www.cabi.org/compendia/cpc.

Example No. 6 – Woolly Cup Grass[6]

SCENARIO: Routine sampling of seed imports by the Canadian Food Inspection Agency, the NPPO of Canada, has led to the detection of woolly cup grass (*Eriochloa villosa*) in millet seed for planting. Woolly cup grass is a regulated weed in seed lots in Canada. A PRA has been initiated to determine if it should also be regulated under Canada's *Plant Protection Act*.

PEST DATASHEET:
Identity: *Eriochloa villosa* (Thunb.) Kunth (Family: Poaceae, Tribe: Paniceae (millet tribe)). Common name: Woolly cup grass.

Habitat: In its native range, *E. villosa* is mainly found in grassy places, roadsides, wastelands, and rice fields. In North America it is primarily a weed of cultivated fields and disturbed soils. It thrives in crop rotations that include maize (e.g. maize-maize or maize-soybean rotations).

Distribution: Origin: Temperate and subtropical Asia (eastern China, Japan, North and South Korea, parts of Mongolia, the Amur and Primorye regions of eastern Russia, and Taiwan). Present: The Caucasus region; western Siberia; the Ukraine; France; the United States (introduced in 13 states but most problematic in the northern, maize growing area (e.g. Illinois, Iowa, Minnesota, Wisconsin)). Absent: Africa; Australasia; most of Europe; Central and South America.

Note: *E. villosa* was reported for the first time in Canada in the summer of 2000, when a small population was noticed growing in experimental barley plots near Montreal, Quebec. The population continued to overwinter and spread until 2002, when the provincial government initiated an eradication program. By 2003 *E. villosa* had been eradicated from the site, and surveillance is ongoing to detect and remove plants that emerge from the seed bank.

Biology and Dispersal: *E. villosa* is a tall annual grass that uses the C_4 photosynthetic pathway, suggesting a possible advantage in hot or dry climates. It is a prolific seed producer, producing up to 164,000 seeds per plant under ideal conditions. Seeds tend to germinate earlier than those of other annual grass weeds, and often germinate continuously over the growing season in a series of germination flushes. Plants produce stolons early and branch extensively later in the season, so that single plants occupy and disperse seed over a large area. Little information is available on dispersal mechanisms, but it is assumed that seed generally falls close to the parent plant, or travels short distances on the wind. Animals may be involved in seed dispersal as well. Humans are an important vector of *E. villosa* seeds, and may disperse them as contaminants in crop seed or through the movement of dirty farm machinery.

Damage: In the United States, *E. villosa* is an increasingly serious pest in maize and soybean crops, particularly in the midwest. It reduces crop yields through competition and increases the cost of weed control. Yield losses in maize have been estimated at up to 50%. In Canada, maize and soybeans are produced primarily in Ontario and Quebec, with the value of maize production estimated at $688 million in 1997.

Control: Woolly cup grass is more difficult to control than many other grass weeds. It requires the integration of cultural and chemical methods, and is tolerant to several of the herbicides used to control other grass weeds in maize. In the United States, increases in producers' operating costs have been estimated at 18% for additional herbicides alone.

[6] **NOTE:** This example was developed specifically for use in the IPPC PRA training course. The scenario is not real. The data sheet is based on the Canadian PRA for *Eriochloa villosa* (CFIA 2002).

Example No. 7 – Raspberry Ringspot Nepovirus[7]

SCENARIO: The Plant Quarantine Organisation of India (Ministry of Agriculture) has received a request to import a new variety of raspberry canes from Germany for propagation. A PRA has been initiated to determine the risk to India's soft fruit industry. A preliminary review of pests in the source country has focussed concern on raspberry ringspot nepovirus (RRSV).

PEST DATASHEET:
Identity: Raspberry ringspot nepovirus (RRSV) (Viruses: Comoviridae: *Nepovirus*). Synonym: Raspberry Scottish leaf curl virus.

Hosts: The main host is raspberries (*Rubus idaeus*), though cultivars differ considerably in susceptibility. Other important hosts include strawberries, cherries, gooseberries, grapes and red currants. RRSV occurs naturally in many species of wild and cultivated plants, with species in more than 14 dicotyledonous families known to be susceptible. Hosts that have been infected experimentally include *Chenopodium amaranticolor* (tree spinach), *Vigna unguiculata* (cowpeas), *Curcurbita* spp., *Iberis saxatilis*, *Nicotiana* spp., *Petunia*, *Paseolus vulgaris*, spinach and tomatoes.

Distribution: Origin: Unknown. Present: Most of Europe (Albania, Austria, Belarus, Belgium, Bulgaria, Czech Republic, Finland, France, Germany, Greece, Hungary, Ireland, Latvia, Luxembourg, Netherlands, Norway, Poland, Slovakia, Slovenia, Spain, Switzerland, Turkey, United Kingdom, Yugoslavia); Kazakhstan; Russia (European and far east); Turkey. Absent: Not recorded in the Americas, Africa, most of Asia, Australia, or New Zealand.

Biology and Dispersal: Many serological variants of RRSV are known and isolates differing considerably in host range and symptomatology are reported. The virus is mechanically transmissible to a number of herbaceous plants and is also transmitted through seed; in some hosts more than 50% of progeny seedlings are infected. Infection of seed, especially in weeds, provides an important means of survival of RRSV in soils. RRSV is also transmitted by two species of the nematode genus *Longidorus*. These free-living, soil-inhabiting vectors are specific for serologically distinctive forms of RRSV; thus, the Scottish and Dutch strains of RRSV are transmitted most efficiently by *L. elongates*, while the English form is transmitted by *L. macrosoma*. Other nematode species (including *Xiphinema diversicaudatum* and other *Longidorus* spp.) have been suspected of transmitting RRSV, but this needs to be confirmed. Both larvae and adults of *L. elongatus* transmit the virus, but the adult does not pass the virus to its progeny, nor is it retained when the nematode moults. Starved *L. elongatus* retain infectivity for up to 9 weeks. *L. elongatus* also transmits tomato black ring nepovirus, which produces identical symptoms and is often found together with RRSV.

Damage: In natural outbreaks, RRSV infection is usually associated with patchy infections in crops, reflecting the distribution of the vector nematode. In infected plants, leaf symptoms, if any, are often dependent on the virus isolate, plant genotype and ill-defined environmental conditions. In raspberry, infection is associated with vein yellowing, mosaic, chlorotic ringspots or flecks, or leaf curling symptoms, depending on the cultivar. Affected strawberry plants may show chlorotic spots or rings or generalized chlorosis. Overall, RRSV causes a severe disease, reducing both growth and fruit yield and sometimes killing plants. It is of great economic importance in Europe. In India, deciduous fruits including pome fruits (apple and pear) and stone fruits (peach, plum, apricot and cherry) are produced in considerable quantity. Soft fruit production in India (including raspberry, strawberry, cherry and grape), was estimated at just over 1 million tons in 2004, with an export value of 25 million USD.

Control: Fumigants such as dazomet or dichloropropane-dichloropropene, directed at the nematode vectors, give good control of virus transmission in raspberry plantations.

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[7] **NOTE:** This example was developed specifically for use in the IPPC PRA training course. The scenario is not real. The data sheet is based on the EPPO Data Sheet URL: http://www.eppo.org/ and CABI Crop Protection Compendium URL: http://www.cabi.org/compendia/cpc, with additional production data from the FAO statistics database URL: http://faostat.fao.org/.

Example No. 8 – Texas Root Rot[8]

SCENARIO: Mexican authorities have stopped a shipment of carrots at the border. The carrots were contaminated with soil, and preliminary investigations indicate that Texas root rot (*Phymatotrichopsis omnivora*) may be a concern. Their department of agriculture (SAGARPA) have initiated a PRA to determine whether the shipment should be allowed to proceed.

PEST DATASHEET:
Identity: *Phymatotrichopsis omnivora* (Duggar) Hennebert (Fungi: Basidiomycetes: Aphyllophorales). Synonyms: *Phymatotrichum omnivorum* Duggar; *Ozonium omnivorum* Shear; *Ozonium auricomum* Link. Telemorph: Possibly *Trechispora brinkmanii* (Bresad.) D. P. Rogers and H. S. Jackson. (Despite some doubt on the association with a specific telemorph, basiodiomycete affinities seem clear). Common name: Texas root rot; cotton root rot.

Hosts: The major host is cotton, including *Gossypium herbaceum*, *G. hirsutum*, and *G. barbadense*. The fungus can also develop on more than 200 species of dicotyledonous plants including 31 economic field crops, 58 vegetable crops, 18 fruits and berries including citrus, 35 forest trees and shrubs, 7 herbaceous ornamentals, and 20 weeds. Monocotyledons are thought to be immune, but fungal strands have been reported on such hosts in nature.

Distribution: Origin: Northern Mexico and southwestern United States (Arizona, Arkansas, California, Louisiana, Nevada, New Mexico, Oklahoma, Texas, Utah). Present: Reported from Venezuela; Lybia. Absent: No confirmed reports from Europe, Asia, or the South Pacific; Africa (except Lybia); most of Central and South America (except Venezuela); northern North America.

Biology and Dispersal: Sclerotia are the primary inoculum source for the initiation of disease. They also serve as over-seasoning propagules that enable the pathogen to persist in soil for many years. Strands have been shown to survive on dead cotton roots for at least one year, but their role in initiating disease in subsequent seasons is not known. Contact with growing roots is made by strands from germinating sclerotia or adjacent infected plants. Strands continue to proliferate on the taproot and associated lesions can be found on lateral roots as the fungus spreads from the taproot into the surrounding soil. The root periderm is penetrated (directly or through lenticels, points of emergence of lateral roots or ruptures in the periderm) with hyphae invading and spreading in the underlying cambium and xylem portions of the root. With field crops such as cotton, sclerotia are formed following infection and plant death. These sclerotia serve as over-seasoning propagules and initiate infections the following growing season.

Damage: The fungus is most serious on cotton; on this host it kills plants before maturity, reduces yield and reduces lint quality in plants which survive until harvest. In Texas, it is estimated that 2% of the cotton yield is lost each year to root rot. Winter-grown annual crops (such as sugarbeet) escape disease. Apples, peaches, pecans, grapes, and in Mexico, mangoes and avocados, suffer significant losses. *Ulmus* spp. have been severely attacked, but the disease in only minor on citrus, roses and *Rhododendron*. In general, there is relatively little information on hosts other than cotton, suggesting that while many species may be infected, few suffer economic loss.

Control: For most crops and soil types, there are no control measures that are both effective and economically justified. Soil fumigants such as 1,3-dichloropropene have been shown to provide control of the pathogen; these treatments may be justified as pre-plant treatments for orchards or vineyards but are cost prohibitive for annual row crops. The application of a systemic triazole fungicide deep in the soil near the root appears to offer the potential for disease reduction. Currently, other control measures (e.g. resistant varieties, biological, cultural) have not yielded adequate or sufficiently consistent reduction in plant mortality to be useful.

[8] **NOTE:** This example was developed specifically for use in the IPPC PRA training course. The scenario is not real. The data sheet is based on the EPPO Data Sheet, URL: http://www.eppo.org/ and CABI Crop Protection Compendium URL: http://www.cabi.org/compendia/cpc

GROUP EXERCISE NO. 3 – PEST RISK ANALYSIS

The objectives of a pest risk analysis (PRA) are, for a specified area, to identify pests and/or pathways of quarantine concern and evaluate their risk; to identify endangered areas; and, if appropriate, to identify risk management options. PRA is defined by three stages, Initiation, Pest Risk Assessment and Pest Risk Management.

PRA is an iterative process. It need not be completed in a linear fashion, question by question, but may be completed instead by inserting information in the appropriate areas as it becomes available and revisiting questions again and again until adequate information has been obtained and a comfort level is reached. Throughout this exercise, you may find yourself jumping forward and going back to revisit questions. This is a very important part of the PRA process.

Use the additional sources of information provided in Appendix 1 to complete the following exercises (these may be divided up over several days):

Group Exercise 3.1 – Initiation, Categorisation and Probability of Introduction – Entry

Group Exercise 3.2 – Pest Risk Assessment: Probability of Introduction – Establishment and Spread

Group Exercise 3.3 – Pest Risk Assessment: Potential Economic Consequences

Group Exercise 3.4 – Pest Risk Assessment: Conclusions

Group Exercise 3.5 – Pest Risk Assessment: Peer Review

Group Exercise 3.6 – Pest Risk Management

Group Exercise 3.7 – Stakeholder Consultation

Document your findings and conclusions and state your sources of information.

PLEASE NOTE:

- The case example provided (including the company information, pest's biology, taxonomy, ecology and information about India and any other country or region named) has been generated specifically for use in this course. While much of the information is based on existing conditions, some of it has been fabricated and as such, the material should not be considered valid for use in actual analyses.
- The pest risk assessment template provided is based on ISPM No. 11: *Pest Risk Analysis for Quarantine Pests, Including Analysis of Environmental Risks and Living Modified Organisms* (2004), and much of the text has been extracted directly from that document. However, the template was designed specifically for use as a training tool and is not an official IPPC standard.

Background information

You are a program officer at the Plant Quarantine Organisation of India (Ministry of Agriculture). Approximately one month ago, you approved the destruction of a consignment of citrus seedlings held at the international airport after a number of live Thysanoptera were collected from the plants. The seedlings were being imported from Africa for the first time, for the purpose of establishing a plantation of a new variety of oranges in the state of Maharashtra. After preliminary identification suggested that the intercepted specimens were citrus thrips, *Scirtothrips aurantii*, you called for the suspension of further shipments of citrus seedlings from the growing facility in Africa, Sunrise Citrus Growers, a subsidiary of SPC (Sunrise Citrus Production), until appropriate measures were taken to ensure freedom of the pest on their products.

Last week, as you were routinely responding to various import requests, your attention was drawn by one particular letter. It read as follows:

Sunrise World Flower Imports Ltd.
Guntur
Andhra Pradesh
India

National Plant Protection Organization
India

Dear NPPO,

We are a newly incorporated company set up to import cut flowers. I would like to check import requirements to begin monthly imports of a variety of cut flower species from a major production facility in Africa.

Under a recently negotiated agreement, our African supplier will airfreight high quality cut flowers to a distribution centre in Uttar Pradesh. There will be a maximum of three days between cutting the flowers in Africa and distributing the flowers from a distribution centre in Uttar Pradesh. The flowers imported will be of top quality since they can be transported in environmentally controlled conditions, ideal for their well-being.

You may be familiar with our sister company, Sunrise Citrus Production (SCP), who is also based in Uttar Pradesh. We will be sharing the same distribution site, which is close to an SCP production area. SCP has a good record of close cooperation with the NPPO.

I would be happy to provide further information if needed.

Sincerely,

Bob Sunrise

What do you do next?

GROUP EXERCISE NO. 3.1 – INITIATION, CATEGORISATION AND ENTRY

Part 1 - Initiation (20 minutes)

The aim of the initiation stage is to identify the pest(s) and pathways which are of quarantine concern and should be considered for risk analysis and to define the PRA area for which the analysis will be conducted. In essence, the Initiation Stage of the PRA describes the scope of the subsequent pest risk assessment and pest risk management stages, by defining the subject matter of the PRA and the area to which it pertains.

1. Identification of initiation points

The PRA process may be initiated as a result of:

- the identification of a pathway that presents a potential pest hazard,
- the identification of a pest that may require phytosanitary measures, or
- the review or revision of phytosanitary policies and priorities.

For PRA initiated as a result of a pest, the organism in question has been screened and has been determined to be a pest by IPPC standards, i.e., it:

- is known to be a pest elsewhere,
- shares characteristics with known pests,
- is related taxonomically to known pests,
- is associated with damage to plants,
- is a known or supposed vector of a known plant pest, or
- is known or suspected of causing damage to beneficial organisms used in plant protection.

Initiation point	
Pathway(s) of concern	
Pest(s) of concern	

2. Identification of the PRA area

The PRA area should be defined as precisely as possible in order to identify the area for which information is needed and which will be considered in all subsequent parts of the PRA. It may be the whole or part of a country, or several countries.

PRA area	Yes [___] No [___] Comment:

3. Review of previous PRAs

A check should be made as to whether pathways, pests or policies have already been subjected to the PRA process, either nationally or internationally. If so, is there a previous PRA which will address the current situation, or do any of these previous PRAs contain information which is pertinent to the current situation and which can contribute to the current PRA?

Previous PRA?	Yes [__] No [__] Comment:

If a previous PRA is still relevant and current, the PRA may stop here (as the previous PRA may suffice). If not, or if previous PRAs are not current or not pertinent, then the PRA may continue.

4. Conclusion of initiation

At the end of Stage 1, the PRA has been initiated and the reasons for the PRA have been stated, i.e., a pathway(s) has been described, an organism has been identified and determined to be a pest, or the reasons for a policy revision have been identified. In addition, the PRA area has been defined. The PRA continues to Stage 2: Pest Risk Assessment.

Part 2 - Pest Risk Assessment - Categorisation (20 minutes)

At the outset, it may not be clear which pest(s) identified in Stage 1 qualify as potential quarantine pests. The categorisation process examines whether the criteria in the definition for a quarantine pest are satisfied for each pest originally identified before the PRA continues.

1. Identity of the pest

- What is the organism?
- Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?
- If the causal agent of particular symptoms has not yet been fully identified, has it been shown to produce consistent symptoms and to be transmissible?

Pest identity	
Pest type	

If the answer is no, the PRA process may stop. Further research may be necessary to go on with the PRA. If the PRA continues, information pertaining to other similar pests may be required and assumptions or areas of uncertainty clearly stated.

2. Presence or absence in the PRA area

- Does the pest occur in the PRA area?
- If so, is the pest widely distributed in the PRA area?

Present in PRA area?	Yes [__] No [__] Comment:
Widely distributed in PRA area?	Yes [__] No [__] Comment:
Important assumptions	

If the pest is present and widely distributed in the PRA area, the PRA may stop (remember the definition of a quarantine pest). If the pest is present in the PRA area, but not widely distributed there, it should be under official control or expected to be under official control in the near future (see Question 3). If the pest is absent from the PRA area, continue with Question 4.

3. Regulatory status

- Is the pest a quarantine pest in the PRA area?
- Is it subject to an official control program?

Regulated in PRA area?	Yes [__] No [__] Comment:
Important assumptions	

If the pest is present in the PRA area and not under official control, the PRA may stop.

4. Potential for establishment and spread in the PRA area

- Does the known area of current distribution of the pest include climatic conditions comparable with those of the PRA area, or sufficiently similar for the pest to survive and reproduce (consider also protected conditions)?
- Does the necessary host(s) plant species (for pests directly affecting plants) or a suitable habitat (for non-parasitic plants) occur in the PRA area (outdoors, in protected cultivation or both)?
- If a vector is the only means by which the pest can spread, is a vector present in the PRA area?

Potential to establish and spread?	Yes [__] No [__] Comment:
Important assumptions	

A preliminary judgement only is required at this stage of the PRA; this is not a full-blown assessment of the pest's potential distribution. Instead, it is a quick comparison of the conditions in the pest's known distribution and the conditions in the PRA area, to determine if the pest meets the specifications of the definition of a quarantine pest. If the answer is no, the PRA may stop. If yes, go to Question 5.

5. Potential for economic consequences in PRA area

- Is the pest known to cause economic or environmental damage elsewhere?
- Are susceptible hosts present in the PRA area? Are they of economic or environmental importance?
- Are there pests present in the PRA that could become more serious if the pest were present (e.g., because it could be an efficient vector)?
- Some organisms may not be known to be harmful in their area of current distribution, but may nevertheless have the potential to become pests in the PRA area. Is this situation a possibility?

Potential for economic consequences?	Yes [__] No [__] Comment:
Important assumptions	

As for the question regarding potential establishment and spread, this is a preliminary judgement of an organism's potential to cause harm and therefore meet the specifications of the definition of a quarantine pest; it is not a full-blown assessment of potential economic impact. If the answer is no, the PRA may stop. If the answer is yes, the PRA will continue.

6. Conclusion of pest categorisation

- Does this organism qualify as a potential quarantine pest for the PRA area? Summarize the main elements leading to your conclusion.

Quarantine pest?	Yes [__] No [__] Comment:
Important assumptions	
Sources of uncertainty	

If it has been determined that the pest has the potential to be a quarantine pest, the PRA process should continue. If a pest does not fulfil all of the criteria for a quarantine pest, the PRA process may stop. In the absence of sufficient information, the uncertainties should be identified and the PRA process should continue.

Part 3 – Pest Risk Assessment, Probability of Entry

Pest introduction is comprised of both entry and establishment. Assessing the probability of introduction requires an analysis of each of the pathways with which a pest may be associated from its origin to its establishment in the PRA area.

A) Identification of pathways (20 minutes)

The probability of entry of a pest depends on the pathways from the exporting country to the PRA area. Their variety, frequency, volume, destination and end-use, and the frequency and quantity of pests associated with each influences the likelihood of the pest entering the PRA area.

The greater the volume and frequency of pathways, the greater the probability of the pest entering the PRA area will be. A good understanding and description of the pathway(s) that a pest or pests may move on contributes to an accurate PRA.

Describe all of the pathways the pest could be carried on:

Documented pathways for the pest to enter new areas should be noted. Potential pathways, which may not currently exist, but are feasible future pathways, should be assessed. Pest interception data may provide evidence of the ability of a pest to be associated with a pathway and to survive in transport or storage.

B) Evaluation of pathways (1 hour)

Each of the pathways identified above should be evaluated in turn, to determine the likelihood that the pest will be associated with it. For each pathway identified, answer the following questions:

1. **Probability of the pest being associated with the pathway at origin**
   - Does the pest occur in the source area? What is its prevalence?
   - Does the pest occur in a life-stage that would be associated with commodities, containers, or conveyances? Do seeds, germ cells, spores or other propagules have access to commodities, containers or conveyances?
   - Is seasonal timing appropriate for the pest to be associated with the pathway at origin?

- What is the volume and frequency of movement along the pathway?
- Are there pest management, cultural and commercial procedures applied at the place of origin that would affect the prevalence of the pest in the pathway? (e.g. application of plant protection products, handling, culling, roguing, grading)
- Has the pest ever been detected or intercepted on the pathway?

Description of Pathway	
Probability of association at origin	
Important assumptions	

2. Probability of survival during transport or storage

- Will the speed and conditions of transport affect the likelihood of the pest surviving? Is the life cycle of the pest of sufficient duration to extend beyond the time in transport and storage?
- How vulnerable are the life-stages that are likely to be transported or stored? (e.g. viability of seeds or propagules for plants, tolerance of low oxygen or high salinity levels for aquatic organisms, or tolerance of extreme temperatures for all organisms)
- What is the prevalence of the pest likely to be associated with a consignment? Is the pest likely to reproduce or increase in prevalence during transport and storage?
- Are there any commercial procedures (e.g. refrigeration, surface treatments, cleaning, controlled atmosphere storage) that are applied to consignments in the country of origin, country of destination, or in transport or storage that could affect the likelihood of the pest surviving?
- Has the pest ever been intercepted alive on a consignment?

Probability of survival on pathway	
Important assumptions	

3. Probability of the pest surviving existing pest management procedures

- Are there existing pest management procedures (including phytosanitary procedures) applied to consignments in the country of origin or the country of destination that would mitigate against the risk of introducing the pest?
- Are there existing pest management procedures (including phytosanitary procedures) applied to consignments against other pests from origin to end-use of the pathway, which would be effective against the pest in question?
- What is the probability that the pest will go undetected during inspection or survive other existing phytosanitary procedures?
- Can the pest be easily distinguished from similar organisms? What is the intensity of the sampling and inspection? Consider where the pest is likely to be found on the commodity, what life stages of the pest may be readily detected on the commodity, how the symptoms of the pest are expressed (e.g. whether they are distinct or whether they resemble those of other pests or sources of damage such as mechanical or cold injury).

Probability of surviving existing measures	
Important assumptions	

4. Probability of transfer to a suitable host

- Will the imported commodity be sent to few or many destination points in the PRA area?
- How close are the points of entry, transit, and destination to suitable hosts in the PRA area? In the case of non-parasitic plants that are pests, suitable habitats may be considered instead of hosts.
- What is the intended use of the commodity? Some uses are associated with a much higher probability of introduction (e.g. planting) than others (e.g. processing).
- At what time of year will the import take place? How likely is the pest to arrive at the time of year most appropriate for establishment?
- Are there dispersal mechanisms, including vectors, that will allow movement from the pathway to a suitable host or habitat?
- Are there any risks of transferring the pest to a suitable host or habitat with by-products and waste?

Probability of finding a host	
Important assumptions	

C) Summary of the probability of entry

What is the likelihood that the pest will enter the PRA area, given the number of pathways identified and the combined risk that they pose? Summarize the main elements leading to your conclusion.

Frequency and volume of pathways	
Probability of entry	
Important assumptions	
Sources of uncertainty	

Points for discussion:

- What additional information would be useful for completing this section and where might it be obtained?
- What is the value of qualitative vs. quantitative information in this section?
- What approaches might be used to summarize the risks posed by different pathways?

Additional Information for Group Exercise 3.1

Sunrise World Flower Imports Ltd.
Guntur
Andhra Pradesh
India

National Plant Protection Organization
India

Dear NPPO,

Thank you for your letter requesting further information about our planned enterprise to import cut flowers. I hope the information below will meet your needs.

- Country of origin: We intend to source our flowers from Kenya.

- Flowers to be imported: *Alstroemeria, Aster, Carthamus, Dendranthema morifolium, Gentianaceae* e.g. *Eustoma grandiflorum, Exacum* etc., *Hedera, Lisianthus* and *Solidago*. If these imports work well, we would like to expand the range of flowers we could import.

- Shipping conditions: Flowers will be harvested by hand, pre-cooled and boxed to prevent heat build up and premature decay. They will be transported to the airport quickly and shipped in cool, but not frozen, containers to maintain the quality of cut flowers.

Please contact me again if you need further information.

Sincerely,

Bob Sunrise

GROUP EXERCISE NO. 3.2 – PROBABILITY OF ESTABLISHMENT AND SPREAD

Part 1 – Pest Risk Assessment, Probability of Establishment (1 hour)

In order to estimate the probability of establishment of a pest, reliable biological information (life cycle, host range, epidemiology, survival etc. in the areas where the pest presently occurs) should be obtained. The situation in the PRA area can then be compared with that in the areas where the pest currently occurs, taking account also of protected environments such as glass- or greenhouses, and expert judgement used to assess the probability of establishment. Use the information provided to answer the following questions:

1. Availability of suitable hosts, alternate hosts and vectors in the PRA area

- What plant species are hosts for the pest? Are hosts and alternate hosts present in the PRA area? How abundant or widely distributed are they? Do they occur in discrete locations or are they distributed contiguously over a wide area? In the case of non-parasitic plants that are pests, suitable habitats may be considered instead of hosts.
- Are some hosts preferred or more susceptible than others? (mature vs. young hosts, healthy vs. stressed hosts, etc)
- In the absence of the usual host species, does the pest have the ability to use new hosts? (host specificity / adaptability)
- Do suitable hosts and alternate hosts occur near ports of entry or major destinations? Do they occur within sufficient geographic proximity to allow the pest to complete its life cycle?
- Does the pest have an active, directed host searching capability?
- Is a vector required for dispersal of the pest, and if so, is it already present in the PRA area or likely to be introduced? Do other potential vectors occur in the PRA area?

Availability of hosts	
Important assumptions	

2. Suitability of environment

- What is the pest's current distribution? Is there evidence of successful introductions in other world regions?
- Are suitable climatic conditions available in the PRA area? Are there any known climatic factors limiting establishment of the pest? Where applicable, consider the climatic factors required for initiation of different life cycle stages (e.g. emergence, mating, egg laying, etc). Consider also the possibility of establishment in a protected environment, e.g. in glasshouses.

- Are suitable climatic conditions available for the host(s) and vector(s) to complete their life cycles in the PRA area? Will the interaction between the pest, host(s) and vector(s) in the area of origin be possible to maintain in the PRA area?
- Are there other abiotic factors that could affect pest establishment? (e.g. soil type, topography, environmental pollution)

Climatic modelling systems may be used to compare climatic data on the known distribution of a pest with that in the PRA area, though models are not necessary to complete this part of the PRA.

Suitability of environment	
Important assumptions	

3. Cultural practices and control measures

- Are there any cultural practices or control measures that could affect pest establishment? Where possible, practices employed during the cultivation / production of the host crops should be compared in the area of origin and the PRA area, to determine if there are similarities or differences.
- Are there natural enemies that could affect pest establishment?
- Is control or eradication possible once the pests is introduced and established? Pests for which control or eradication is not feasible may present a greater risk than those for which treatment is easily accomplished.

Cultural practices and control measures	
Important assumptions	

4. Other characteristics of the pest affecting the probability of establishment

- Will the pest be able to reproduce in the PRA area? How many generations are possible? Are there reproductive strategies that might confer an advantage? Consider characteristics such as parthenogenesis / self-crossing, duration of the life cycle, number of generations per year, resting stage, etc.
- Is the species polymorphic? Does it have a demonstrated ability to adapt to new habitats or hosts? Genotypic (and phenotypic) variability facilitates a pest's ability to withstand environmental fluctuations, to adapt to a wider range of habitats, to develop pesticide resistance and to overcome host resistance.
- Is there a threshold population required for establishment?

- Is there a requirement for alternate hosts, dormancy or vectors which make establishment more or less likely?

Other characteristics affecting establishment	
Important assumptions	

5. Summary of the probability of establishment

In summary, what is the anticipated final distribution of the pest relative to its hosts' distribution in the PRA area?

Probability of establishment	
Important assumptions	
Sources of Uncertainty	

Points for discussion:

- What additional information would be useful for completing this section and where might it be obtained?
- What is the value of qualitative vs. quantitative information in this section?
- What are some of the climatic models that could be used to estimate the pest's range in the PRA area? What are the advantages and disadvantages of using climatic models instead of manual climate matching with maps and data?

Part 2 – Pest Risk Assessment, Probability of Spread (1 hour)

Information on probability of spread is used to estimate how rapidly a pest's potential economic (or environmental) importance may be expressed in the PRA area and is directly linked to its potential distribution. A pest with a high potential for spread may also have a high potential for establishment, possibilities for its successful containment and/or eradication may be more limited, and therefore its impacts more difficult to overcome.

In order to estimate the probability of spread of the pest, reliable biological information should be obtained from areas where the pest currently occurs. Information pertaining to movement of commodities, pest interception reports and historical accounts of the pest's spread in other areas where it has been introduced may contribute to assessment of its potential for human-assisted transport; in many cases of PRAs for which pathways are being considered, these pathways are the means by which human-assisted spread may occur.

The situation in the PRA area can then be carefully considered and expert judgement used to assess the probability of spread. Use the information provided to answer the questions which follow.

1. Natural spread potential

- Do suitable natural and/or managed environments exist in the PRA area for natural spread of the pest? Consider the host range of the pest, and the distribution and abundance of suitable hosts (contiguous distribution?), as well as any known climatic factors that might limit the spread of the pest.
- What is the pest's ability for natural dispersal, e.g., long distance flight, wind-borne transport of spores etc.? What is the pest's natural rate of spread per year?
- What is the pest's reproductive potential?
- Are there natural barriers to spread of the pest in the PRA area? Are vectors required for the pest to spread, and if so are they present in the PRA area? Are there natural enemies that may affect the pest's ability to spread in the PRA area?

Natural spread potential	
Important assumptions	

2. Human-assisted spread potential

- Does the pest have the ability to use human activity for dispersal?
- Is the pest likely to move with commodities or conveyances?
- Does the intended end-use of the commodity have implications for the spread of the pest?

- Are there industry practices which contribute to human-assisted transportation, such as exchange of germplasm between growers of a particular crop kind?

Human-assisted spread potential	
Important assumptions	

3. Other factors affecting the probability of spread

- What is the likelihood of early detection of a newly established population based on visual observation?
- Is the spread of the pest likely to extend beyond the PRA area?
- Are there currently measures in place that would effectively slow or stop spread from occurring?

Other factors affecting spread	
Important assumptions	

4. Summary of the probability of spread

In summary, how rapidly will the pest spread within the PRA area if it enters and becomes established?

Probability of spread	
Important assumptions	
Sources of uncertainty	

Points for discussion:

- What additional information would be useful for completing this section and where might it be obtained?
- What is the value of qualitative vs. quantitative information in this section?
- What are some of the challenges involved in estimating spread potential (time and space factors; probability of spread vs. rate and extent of spread; natural spread vs. human-assisted spread)?

Conclusion of the probability of introduction and spread

The overall probability of introduction and spread should be expressed in terms most suitable for the data, the methods used for analysis, and the intended audience. This may be quantitative or qualitative, since either output is the result of a combination of both quantitative and qualitative information. The probability of introduction may be expressed as a comparison to other better-known pests, or other pests for which PRAs are available.

Since introduction includes both entry and establishment, estimate the overall probability of introduction and spread of the pest based on the individual assessments (above) of entry, establishment and spread potential.

Overall Probability of Introduction and Spread	
Important Assumptions	
Sources of uncertainty	

Points for Discussion

- Are entry, establishment and spread equally important factors in assessing a pest's overall introduction potential?
- What challenges are faced when combining subjective assessments for different characteristics, such as entry potential and establishment potential?
- How can these challenges be addressed most effectively?

GROUP EXERCISE NO. 3.3 – POTENTIAL ECONOMIC CONSEQUENCES

A pest may have direct or indirect effects and these may be economic, environmental or social. In a pest risk assessment, each effect is evaluated separately and then combined in order to reach a conclusion on a pest's overall potential consequences.

Requirements described in this step indicate the information which should be assembled, and suggest levels of economic analysis that may be carried out using that information in order to assess the various potential effects of the pest. Wherever appropriate, quantitative data should be used, though qualitative data may also be used. Consultation with an economist may be useful.

In order to estimate the potential economic importance of the pest, information should be obtained from areas where the pest occurs naturally or has been introduced. This information should be compared with the situation in the PRA area. Case histories concerning comparable pests can usefully be considered. Use the information provided to answer the following questions:

1. Direct economic effects

- What are the known or potential host plants, including those in the field, under protected cultivation, or growing in the wild (generate a list)? Are any of the hosts of economic importance? If so, provide data to show how much importance.
- What are the types, amount and frequency of damage caused by the pest? Are some host species more susceptible than others?
- Does the pest cause crop losses, in yield and quality? If so, how much? What revenue losses can reasonably be expected?
- Are there other biotic factors (e.g. adaptability and virulence of the pest) that may affect damage and losses? If yes, list them.
- Are there abiotic factors (e.g. climate) that may affect damage and losses? If yes, list them.
- What is the pest's rate of reproduction and spread?
- What measures exist for control of the pest, and what is their efficacy and cost?
- What effect might the pest have on existing production practices in the PRA area? Consider changes in production methods and associated costs.
- Would presence of the pest necessitate additional costs over those already incurred in production of the commodity? If so, what are they?

For each of the potential hosts, the total area of the crop and area potentially endangered should be estimated in relation to the elements given above. Note also that economic consequences are expressed over time, and may be felt in one year, several years, or over an indeterminate period. Various scenarios should be considered.

Using the information provided, describe and estimate the direct economic effects of the pest if it were to be introduced and spread? If possible, predict the time period over which these effects would be felt.

Direct economic effects	
Important assumptions	

2. Direct environmental effects

- How likely is it that the pest will cause a reduction of keystone plant species (i.e., plant species that are of fundamental importance to the maintenance and character of the ecosystem in which they are found)?
- How likely is the pest to cause a reduction in plant species that are major components of ecosystems (in terms of abundance, size or ecological importance), and endangered native plant species, including effects below species level where there is evidence of such effects being significant?
- Could the pest cause significant reduction, displacement or elimination of other plant species? If so, describe.

Note that environmental effects and consequences considered should result from effects on plants, whether direct or indirect. Such effects may be less significant than the pest's effects on other organisms or systems, but the regulation of pests solely on the basis of effects on other organisms or systems (e.g. human or animal health) is outside the scope of ISPM No. 11.

Using the information available, describe and estimate the potential direct environmental effects of the pest.

Direct environmental effects	
Important assumptions	

3. Indirect economic effects

- How likely is introduction of the pest to cause effects on domestic and export markets, including in particular export market access? The potential consequences for market access which may result if the pest becomes established, should be estimated, including the extent of any phytosanitary regulations imposed (or likely to be imposed) by trading partners.
- Could introduction of the pest cause changes to producer costs or input demands, including control costs? If yes, how?
- Could introduction of the pest cause changes to domestic or foreign consumer demand for a product resulting from quality changes, loss of marketability, and/or diversion of the product to a lower value end-use?
- Could the pest act as a vector for other pests?
- Once introduced, would eradication or containment of the pest be feasible? How much would it cost?
- Would resources be needed for additional research and advice? If yes, estimate how much.

- Could the pest have social and other effects (e.g. tourism)? If yes, describe.

Using the information available describe and quantify, as much as possible, the potential indirect economic effects of the pest should it be introduced and spread.

Indirect economic effects	
Important assumptions	

4. Indirect environmental effects

- How likely is the pest to have significant effects on plant communities through competition for resources?
- How likely is the pest to have significant effects on designated environmentally sensitive or protected areas?
- How likely is the pest to cause significant changes in ecological processes and the structure, stability or processes of an ecosystem (including further effects on plant species, erosion, water table changes, increased fire hazard, nutrient cycling, etc)?
- Could the pest affect human use of resources (e.g. water quality, irrigation / navigation, recreational uses, tourism, animal grazing, hunting, fishing)? If so, how?
- Would there be environmental and other undesired effects of control measures? If so, what are they?
- Would there be costs associated with environmental restoration? If so, what are they?

Using the information available, describe and estimate the potential indirect effects of the pest should it be introduced and spread within the PRA area.

Indirect environmental effects	
Important assumptions	

5. Conclusion of the assessment of economic consequences

Wherever appropriate, the output of the assessment of economic consequences described in this step should be in terms of a monetary value. The economic consequences can also be expressed qualitatively or using quantitative measures without monetary terms. Sources of information, assumptions and methods of analysis should be clearly specified.

Overall economic and environmental consequences	

Important assumptions	
Sources of uncertainty	

Points for discussion:

- What additional information would be useful for completing this section and where might it be obtained?
- What is the value of qualitative vs. quantitative information in this section?
- What are some of the analytical techniques that can be used to assess the potential economic effects of a pest?
- What are some of the techniques that can be used to assess the non-commercial and environmental effects of a pest?
- If time permits, draw a simple conceptual model / framework and annotate aspects that could be quantified.

Conclusion regarding endangered areas

The endangered area is that area of the PRA area in which ecological and other conditions favour establishment of the pest and wherein economically important loss may occur. Definition of the endangered area, therefore, draws on the conclusions of the assessments of potential distribution and potential impacts. The Endangered Area may be all or part of the PRA Area.

Using the information provided, describe the endangered area in relation to the PRA area.

Endangered Area	
Criteria	
Important Assumptions	
Sources of uncertainty	

Points for discussion

- What were your criteria for selecting this area over another?
- What are the benefits or costs of distinguishing an endangered area that is different from the PRA area?

GROUP EXERCISE NO. 3.4 – PEST RISK ASSESSMENT CONCLUSIONS

At the end of Stage 2: Pest Risk Assessment, an overall assessment of risk will have been estimated for each of the pests included in the PRA, and an endangered area will have been defined if required. The overall assessment incorporates the elements of probability (entry, establishment, and spread) and potential impacts (direct and indirect, economic and environmental) which have so far been considered separately.

Based on the overall assessment, a determination of whether the estimated risk is acceptable or not is made for each pest. For those pests, whose estimated risk is considered acceptable, the PRA may stop. For those that present an unacceptable risk, the PRA may continue. The estimation of overall pest risk, therefore, is a very important final step in pest risk assessment.

ISPM No. 2 and ISPM No. 11 do not provide guidance on how to combine the elements that have been considered in Stage 2 or how to draw conclusions regarding the overall risk of a pest or pests. They, likewise, do not provide instructions for determining if a specified level of risk is acceptable or not. Expert judgement acquired through experience with PRA and consultation with others is required. Different approaches have been taken by various NPPOs; the common feature of all of these is their interpretation of risk as a product of likelihood and impact.

Using the information documented so far and keeping in mind this interpretation of risk, devise a scheme for summarizing the overall risk posed by the pest in this PRA and for determining if the level of risk is acceptable or not. You may or may not wish to assign ratings. The summary table provided on the next page may be useful but you may prefer to devise your own system. Keep in mind that it is also important to document the areas of uncertainty and the degree of uncertainty in the assessment, and to indicate where expert judgement has been used.

Questions to consider in devising your scheme:

- Are likelihood elements (entry, establishment and spread) and impact elements (economic or environmental effects) equally important or are some elements more important than others?
- How can quantitative and qualitative data be incorporated into a single conclusion?
- Is consistency between risk assessments an important feature? Will my model help to achieve that?
- How can I demonstrate how the overall conclusion was reached?
- How should the overall risk be expressed? Numerically? Descriptively?
- What considerations would influence a decision about whether or not a specified level of risk was acceptable?
- Will my overall risk assessment conclusion provide the necessary information to determine if the risk is acceptable, or not, as required at the end of Stage 2?
- Have I sufficiently documented my findings, sources of information and conclusions?

Pest Risk Assessment Summary Sheet

STAGE 1: INITIATION	
Initiation point	
PRA area	
STAGE 2: PEST RISK ASSESSMENT	
Pest identity	
Pest type	
Present in PRA area?	Yes [__] No [__] Comment:
Meets specifications of the definition of a quarantine pest?	Yes [__] No [__] Comment:
Type(s) and volumes of pathways	
Probability of entry	
Probability of establishment	
Probability of spread	
Overall probability of introduction and spread	
Sources of uncertainty	
Potential direct economic consequences	
Potential direct environmental consequences	
Potential indirect economic consequences	
Potential indirect environmental consequences	
Overall potential consequences	
Sources of uncertainty	

Overall risk (combination of likelihood and consequences)	
Overall uncertainty	
Considerations	
Overall risk is Acceptable or Unacceptable	(If the risk is acceptable, the PRA may stop here; if the risk is unacceptable, the PRA continues to Stage 3: Pest Risk Management)

GROUP EXERCISE NO. 3.5 – PEST RISK ASSESSMENT, PEER REVIEW

Peer review is a valuable process for ensuring scientific validity, consistency and transparency in the PRA process. This process is often first done internally in order to ensure that all parties within the NPPO are in agreement with the PRA before it is released to external groups.

In this exercise, each group will present its Pest Risk Assessment to the other group for peer review. Participants will assume the role of experts within the same NPPO. Each group will be called upon to present its pest risk assessment for review and, in turn, to review the pest risk assessment presented by the alternate group.

Take 10 minutes to organize your presentation; be prepared to explain and justify the conclusions you have reached so far in your assessment and present your findings to the other group. Be prepared to listen to their comments, incorporate new information and make changes based on new information they present.

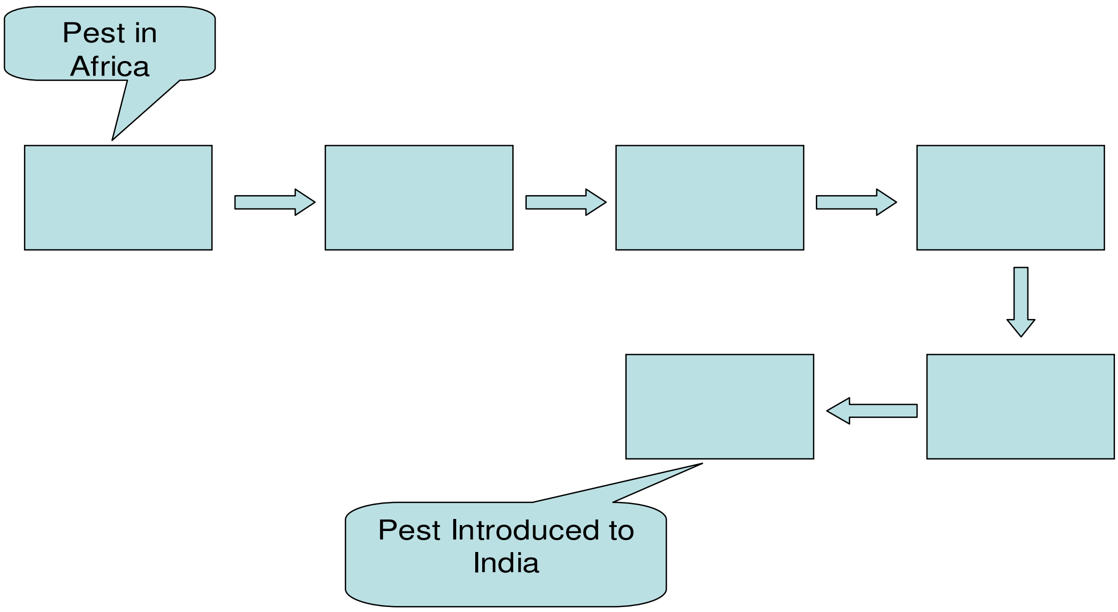
Be prepared, also, to listen to the presentation of the other group's pest risk assessment and provide constructive suggestions for its improvement.

GROUP EXERCISE NO. 3.6 – PEST RISK MANAGEMENT

For those pests presenting unacceptable risks, the conclusions of the pest risk assessment are used to support decisions on the strength and nature of measures to be used to reduce those risks to an acceptable level. Pest risk management, therefore, is the process of evaluating and selecting risk management options to reduce the risk of the pest(s) identified in the pest risk assessment.

Mitigation measures may be applied at different stages between origin of the pathway and its final destination. A scenario diagram detailing the sequence of events between the pest's first association with the pathway and its establishment in the PRA area helps to identify key areas where mitigation measures may be applied effectively.

Outline the sequence of events that must take place for *Scirtothrips aurantii* to be introduced to India following importation of cut flowers from Africa. Identify points along this timeline at which mitigation measures could be applied. More boxes can be added to the diagram below if required.



ISPM No. 11 and the Participant Manual provide suggestions for the types of management options that may be available at different points in the continuum between a pest's origin and its destination in the PRA Area. In the table below, list the types of measures that would be available under the categories listed in ISPM No. 11 and for each example note potential costs, benefits or limitations there may be in their applicability, feasibility or efficacy in the case in question. More rows may be added if required.

For each option, consider the following questions:

- What are the possible responses to this pest?
- Are measures available?
- What impacts, positive and negative, might be expected if these measures are applied?
- What are the costs of each option?
- Is the option operationally feasible?
- Will it work?
- Is feasibility dependant on outside influences?

<table>
<tr><th>Point of Intervention</th><th>Management Options</th><th>Costs, Benefits or Limitations to Consider</th></tr>
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The conclusion of the pest risk management stage will be either that no measures are identified which are appropriate to address the identified pest risk, or that one or more management options (or series of options) is appropriate to lower the pest risk to an acceptable level.

Based on your information from the table above, identify two equivalent measures (or series of measures) which are appropriate to mitigate the pest risk identified in this scenario. These measures will form the basis of future phytosanitary regulations or requirements.

	Option A	Option B	Option C
Effective			
Feasible			
Efficient			
Conclusion			

Points for Discussion:

- What criteria did you consider in evaluating each option or in selecting preferred options?
- What principles of the IPPC should be remembered during the pest risk management stage?
- What are the most challenging aspects of the pest risk management stage?
- What are some things that an NPPO could do to make this stage of the PRA easier?

GROUP EXERCISE NO. 3.7 – STAKEHOLDER CONSULTATION

Pest risk communication does not begin at the conclusion of the pest risk management stage. It is an ongoing, two-way process which occurs before, during and after the PRA is completed. Pest risk communication takes many forms, including personal communications, face-to-face informal gatherings, written correspondence, formal presentations or structured consultations. Each stage has its purpose, audience and challenges.

This week, we have considered the case of a phytosanitary inspector who detects live insects in a shipment of cut flowers imported to India from an African country. We have completed a pest risk assessment, considered and evaluated possible mitigation measures and concluded that mitigation measures are necessary and available.

In this exercise, each group will assume the role of a particular party in this scenario, i.e., the NPPO, the importer, or a domestic producer, and will consider the situation from that point of view. After 30 minutes preparation time, the groups will reconvene for a public meeting, at which the NPPO will present its PRA, the proposed response to the current interception and a proposed new import requirement for cut flowers from Africa. The importer and domestic producer groups will ask questions and present their points of view on this issue.

Group 1: NPPO representatives

You are a phytosanitary official in the NPPO of India. You have completed your PRA and have identified possible mitigation measures (or sequence of measures) which will provide satisfactory protection to deal with the pest in question, and have drafted revised import regulations to prevent future introductions on this pathway. IPPC member countries are obligated to publish phytosanitary requirements and share information on pests and regulations.

Prepare to inform stakeholders of new import requirements resulting from the PRA that has just been completed. Be ready to answer questions which will arise.

Group 2: Importers of cut flowers in India

You have traditionally imported cut flowers from Africa without phytosanitary restrictions for several years. You have a customer who is buys large orders of cut flowers from Africa. You have been informed that the NPPO is conducting a PRA and will inform you of revised import requirements shortly.

What are your questions for the NPPO? Do you have concerns regarding restrictive import requirements? What will be the impact on your business if import restrictions are put in place?

Group 3: Domestic producers association

You are members of a large domestic producers' association with interests in a wide range of agricultural and horticultural products in India. Your members own and operate farming operations that employ many hundreds of people and produce food and plant products for sale on the domestic and export market. What are your concerns in this situation? What is your position with respect to the decision your NPPO is taking?

Prepare to present your arguments to your NPPO in defence of your position. Explain your position. Identify others who support this position.

Points for Discussion:

- Who are the potential stakeholders in this issue?
- Besides stakeholders, who else should be consulted?
- What are their potential concerns?
- How might these concerns be addressed?
- What communications strategies could be employed in this instance?

GROUP EXERCISE NO. 4 – IMPACTS

Impacts of a pest's introduction and spread may take many forms; they may be economic, environmental or social impacts; and they may be direct or indirect. It is important when doing a PRA to consider all of the potential impacts and the costs and benefits of importing the commodity. Sometimes the benefits of importing a commodity outweigh the risks, or vice versa.

The objective of this exercise is to identify all the possible impacts that could be experienced if woolly cup grass were to be introduced to Canada. For this exercise, break into 2 groups and use the woolly cup grass fact sheet from group exercise no. 2.

Group one will consider and list of all the potential direct consequences of the introduction of woolly cup grass to Canada.

Group two will consider and list of all the potential indirect consequences of the introduction of woolly cup grass to Canada

The group will re-convene and both groups will present their views. There will then be a 5 – 10 minute group discussion.

GROUP EXERCISE NO. 5 – MITIGATION MEASURES

Mitigation measures may be applied to commodities, packing materials, means of transportation, or other elements of a pathway. The purpose of applying measures is to reduce the estimated level of pest risk to an acceptable level. Mitigation measures may take many forms, ranging from chemical or physical treatments to restrictions on distribution or end-use. Each measure has a unique effect on pest risk depending on the target species, the pathway, the circumstances of its application and other factors.

A helpful resource for an NPPO is a list of possible mitigation measures to consider during the pest risk management stage of the PRA.

In this exercise, participants will work as a group to develop a comprehensive list of mitigation measures that might be considered during the pest risk management stage of a PRA for any pest or pathway.

The following table is an <u>example</u> of a way in which the list of mitigation measures might be organized. Other formats may be equally or more useful.

Types of Measures	Measures	Pathway Point A	Pathway Point B	Pathway Point C	Pathway Point D	Etc.
Chemical	Mitigation Measure					
	Mitigation Measure					
	Etc.					
Physical	Mitigation Measure					
	Mitigation Measure					
Etc.	Etc.					

Develop a list which identifies:

- Different points along a pathway where measures might be applied
- Different types of measures

For each point, indicate which types of measures might be applicable.

GROUP EXERCISE NO. 6 – PEST RISK MANAGEMENT

Pest risk management is a process of determining appropriate management options to reduce the risks identified in the pest risk assessment to an acceptable level.

Scenario:

A country on the opposite side of the world from yours has a successful tomato growing industry. The country's NPPO has contacted your NPPO and requested your country's import requirements for their tomatoes. Your country does not currently have import requirements for tomatoes so you reply to the other country asking them for information about the pests they have on tomatoes and their associated agricultural production systems. The letter you receive in reply is as follows:

> Dear NPPO,
>
> Our tomato industry is one of the best in the world at producing low cost, high quality product. Our climate is perfectly suited to large scale outdoor production of tomatoes that are hand picked, packaged and refrigerated for maximum quality and freshness. Our tomato industry is formed from a co-operative of many small to medium growers that maintain their own production management systems but share large scale packaging and refrigeration facilities. We have a number of pests that affect our tomato production but our scientists tell us that only one of these pests is not already established in your country - the tomato fruit beetle, *Dispictus tomatocus*.
>
> We look forward to hearing from you soon and shipping our first consignment of delicious tomatoes to your country.
>
> Regards

Information about the country suggests that they do produce large volumes of low cost tomatoes but the quality of the tomatoes is not always consistent, suffering from mechanical damage, varying ripeness, inconsistent size or shape, and pest injury and contamination.

Information about the tomato fruit beetle, *Dispictus tomatocus*, indicates that the adults lay their eggs on mature or nearly mature fruit. Symptoms of infestation only become apparent several days later once the larvae begin to move under the skin of the tomato. Larvae mature within 15 days unless the weather is cooler than normal and the larvae go into a dormant stage surviving for up to 6 months.

You have completed a risk assessment which concludes that the tomato fruit beetle risk associated with imported fresh tomatoes is unacceptable. You proceed to Stage 3 of the PRA process to consider potential mitigation measures which would lower the level of overall risk to an acceptable level.

When all the risk management options have been identified for a particular risk or group of risks, they should each be evaluated to ensure they will mitigate the risk to the desired level either alone or in combination with other measures. At the same time it is also useful to evaluate each option to ensure they are feasible or applicable to the context in which they are to be applied.

For the scenario described above, identify potential risk management options from the list developed in today's group discussion. Analyse these options against the criteria listed in the table below. Note what type of information would be required to complete the risk management stage of this PRA and potential sources for that information.

Potential management options	Effectiveness	Efficiency	Reproducibility	Cost effectiveness	Potential adverse consequences	Costs	Indirect impacts

GROUP EXERCISE NO. 7 – RISK COMMUNICATION

The Ministry of Transportation in your country recently imported a type of plant to be used on roadsides to prevent soil erosion. The plant, "creeping land vine" (*Vinus copius*), is a fast growing perennial vine that rapidly spreads over large areas of ground, sending roots deep into the soil (hence its use to prevent soil erosion). Reproduction is both vegetative and sexual. Vegetative reproduction is through rhizomes and runners. Sexual reproduction occurs during the dry season when the plant forms small pods. These pods burst open and produce seeds that are easily windborne, adding to the dispersal ability of this plant.

According to the Ministry of Transportation, this plant has done an excellent job of preventing soil erosion near roads. They are counting the "Creeping Land Vine Project" as a major success. Unfortunately, your service is now receiving complaints from farmers in the area claiming that creeping land vine is reducing production of crops. In addition, an environmental lobby group is concerned that creeping land vine may invade a major conservation area in your country, causing widespread environmental harm.

Your supervisor has requested you to conduct a stakeholder consultation to address this difficult issue. Formulate a strategy for your stakeholder consultation taking into account what has already been discussed in this meeting and drawing from your own experience. In formulating your communication strategy, you will first need to identify the purpose and objective(s) of the consultation. You will need to identify your target audience(s) / stakeholders and identify specific information you wish to communicate to the stakeholders. Likewise, you may also wish to consider and identify what information you may need to obtain from your audience / stakeholders (keeping in mind that stakeholder consultations can involve an exchange of information rather than a one-way flow of information). It may also be useful to identify what approach(es) might you use to try to balance the opposing points of view in this situation.

GROUP EXERCISE NO. 8 – PEST RISK ASSESSMENT REVIEW

Example No. 1 – Butternut Canker

SCENARIO: Several European countries have received requests to import nursery stock plants of walnut (*Juglans* spp.) from North America. The request is to import field grown 2-4 year old bareroot plants from northeastern US states.

At their request, the European and Mediterranean Plant Protection Organization (EPPO) has agreed to conduct a PRA. One of the primary pests of concern is the butternut canker (*Sirococcus clavigignenti-juglandacearum*).

Using the pest facts sheet provided for Butternut Canker in Group Exercise No. 2, Pest Categorisation:

- Complete as much of the Pest Risk Assessment Summary Table below as possible.
- Identify further information that is required to complete the Pest Risk Assessment

STAGE 1: INITIATION	
Initiation point	
PRA area	
STAGE 2: PEST RISK ASSESSMENT	
Pest identity	
Pest type	
Present in PRA area?	Yes [__] No [__] Comment:
Meets specifications of the definition of a quarantine pest?	Yes [__] No [__] Comment:
Type(s) and volumes of pathways	
Probability of entry	
Probability of establishment	
Probability of spread	
Overall probability of introduction and spread	

Sources of uncertainty	
Potential direct economic consequences	
Potential direct environmental consequences	
Potential indirect economic consequences	
Potential indirect environmental consequences	
Overall potential consequences	
Sources of uncertainty	
Overall risk (combination of likelihood and consequences)	
Overall uncertainty	
Considerations	
Overall risk is Acceptable or Unacceptable	(If the risk is acceptable, the PRA may stop here; if the risk is unacceptable, the PRA continues to Stage 3: Pest Risk Management)

Missing Information:

-
-
-
-
-

Example No. 2 – Raspberry Ringspot Nepovirus

SCENARIO: The Plant Quarantine Organisation of India (Ministry of Agriculture) has received a request to import a new variety of raspberry canes from Europe for multiplication and propagation in India. Production of temperate fruits in India is on the rise; deciduous fruits including pome fruits (apple and pear) and stone fruits (peach, plum, apricot and cherry) are produced in considerable quantity and soft fruits are similarly increasing in popularity. Soft fruit production in India, namely raspberry, strawberry, cherry and grape, was estimated at just over 1 million tons in 2004, with an export value of 25 million USD.

A PRA has been initiated to determine the risk to India's soft fruit industry presented by the potential importation of canes from Europe. A preliminary review of pests in Europe has focussed concern on raspberry ringspot nepovirus (RRSV).

Using the pest facts sheet provided for Raspberry Ringspot Virus in Group Exercise No. 2, Pest Categorisation:

- Complete as much of the Pest Risk Assessment Summary Table below as possible.
- Identify further information that is required to complete the Pest Risk Assessment

STAGE 1: INITIATION	
Initiation point	
PRA area	
STAGE 2: PEST RISK ASSESSMENT	
Pest identity	
Pest type	
Present in PRA area?	Yes [__] No [__] Comment:
Meets specifications of the definition of a quarantine pest?	Yes [__] No [__] Comment:
Type(s) and volumes of pathways	
Probability of entry	
Probability of establishment	
Probability of spread	
Overall probability of introduction and spread	

Sources of uncertainty	
Potential direct economic consequences	
Potential direct environmental consequences	
Potential indirect economic consequences	
Potential indirect environmental consequences	
Overall potential consequences	
Sources of uncertainty	
Overall risk (combination of likelihood and consequences)	
Overall uncertainty	
Considerations	
Overall risk is Acceptable or Unacceptable	(If the risk is acceptable, the PRA may stop here; if the risk is unacceptable, the PRA continues to Stage 3: Pest Risk Management)

Missing Information:

-
-
-
-
-

Example No. 3 – Woolly Cup Grass

SCENARIO: Routine sampling of seed imports by the Canadian Food Inspection Agency has led to the detection of woolly cup grass (*Eriochloa villosa*) seeds in millet seed for planting. Woolly cup grass is listed as a prohibited noxious weed in Canada's national seed regulations. A PRA has been initiated to determine if it should also be considered as a plant quarantine pest.

Using the pest facts sheet provided for Woolly cup grass in Group Exercise No. 2, Pest Categorisation:

- Complete as much of the Pest Risk Assessment Summary Table below as possible.
- Identify further information that is required to complete the PRA

STAGE 1: INITIATION	
Initiation point	
PRA area	
STAGE 2: PEST RISK ASSESSMENT	
Pest identity	
Pest type	
Present in PRA area?	Yes [___] No [___] Comment:
Meets specifications of the definition of a quarantine pest?	Yes [___] No [___] Comment:
Type(s) and volumes of pathways	
Probability of entry	
Probability of establishment	
Probability of spread	
Overall probability of introduction and spread	
Sources of uncertainty	
Potential direct economic consequences	
Potential direct environmental consequences	

Potential indirect economic consequences	
Potential indirect environmental consequences	
Overall potential consequences	
Sources of uncertainty	
Overall risk (combination of likelihood and consequences)	
Overall uncertainty	
Considerations	
Overall risk is Acceptable or Unacceptable	(If the risk is acceptable, the PRA may stop here; if the risk is unacceptable, the PRA continues to Stage 3: Pest Risk Management)

Missing Information:

-
-
-
-
-

EPPO quarantine pest

Prepared by CABI and EPPO for the EU
under Contract 90/399003

Data Sheets on Quarantine Pests

Scirtothrips aurantii

IDENTITY

Name: *Scirtothrips aurantii* Faure
Synonyms: *Scirtothrips acaciae* Moulton
Taxonomic position: Insecta: Thysanoptera: Thripidae
Common names: South African citrus thrips (English)
Thrips sud-africain des agrumes (French)
Citrusblasenfuss (German)
Bayer computer code: SCITAU
EPPO A1 list: No. 221
EU Annex designation: II/A1

HOSTS

Although usually considered to be associated with *Citrus*, especially oranges (*C. sinensis*) in Southern Africa, *S. aurantii* has been found on more than 50 plant species in a wide range of different plant families, and is sometimes a pest of mangoes (*Mangifera indica*) when these are grown close to citrus trees in South Africa. Its native hosts are probably *Acacia* and *Combretum* trees, but it has also been taken on a range of crops that are not only botanically unrelated but differ widely in form, including *Arachis*, *Asparagus*, *Gossypium*, *Musa*, *Ricinus* and *Vitis*.

GEOGRAPHICAL DISTRIBUTION

S. aurantii is native to Africa, and the only records considered to be valid (i.e. supported by voucher specimens in an available collection) from outside this continent are from Yemen.
EPPO region: Egypt.
Asia: Yemen.
Africa: Angola, Cape Verde, Egypt, Ethiopia, Ghana, Kenya, Malawi, Mauritius, Nigeria, Réunion, South Africa, Sudan, Swaziland, Tanzania, Uganda, Zimbabwe.
EU: Absent.
Distribution map: See CIE (1961, No. 137).

BIOLOGY

All stages feed on epidermal, or even palisade, cells of young leaves, and on the apex of young fruit often concealed under the calyx (Milne & Manicom, 1978). They do not feed on mature leaves (Hall, 1930). Eggs are inserted into young tissues. There are two nymphal (feeding) stages, followed by two pupal (non-feeding) stages. Pupation occurs on the ground amongst leaf litter; pupae occur rarely beneath the calyx of fruits. Breeding is almost continuous, although development is slow in winter, and the life history can he completed in less than 30 days.

Adults are probably dispersed downwind, but observations in South Africa have suggested that early-season infestations in citrus orchards develop mainly from thrips that have overwintered within each orchard, rather than from adults flying in from wild plants (Gilbert, 1990). Later in the season (November and December), wild hosts probably assume greater importance as a source of the pest. Citrus trees close to windbreaks of *Grevillea* trees (that harbour *S. aurantii*) had more severe fruit scarring than citrus trees close to windbreaks of *Pinus* or *Casuarina* trees (these do not support *S. aurantii*) (Grout & Richards, 1990a).

DETECTION AND IDENTIFICATION

Symptoms

Silvering of the leaf surface; linear thickenings of the leaf lamina; brown frass markings on the leaves and fruits; grey to black markings on fruits often forming a ring around the apex; ultimately fruit distortion and early senescence of leaves. If flushes of young leaves are severely attacked later in the season, then the crop of the following season may be reduced (Kamburov, 1991).

Morphology

Members of the genus *Scirtothrips* are readily distinguished from all other Thripidae by the following characters: surface of pronotum covered with many closely spaced transverse striae; abdominal tergites laterally with numerous parallel rows of tiny microtrichia; sternites with marginal setae arising at posterior margin; metanotum with median pair of setae arising near anterior margin. The only closely similar species is *Drepanothrips reuteri*, a native European pest of grapevine, but that has the antennae 6-segmented (the 3 terminal segments being fused) instead of 8-segmented. Most of the 59 species described in *Scirtothrips* were defined originally by their authors on unreliable colour and silhouette characters; Mound & Palmer (1981) describe many structural details by which each pest species may be distinguished. Many undescribed species are known from Central America (Mound & Marullo, in press). *Scirtothrips* spp. primarily infest young growing buds, so these should be examined particularly carefully.

In *S. aurantii*, the eggs are bean-shaped, minute (less than 0.2 mm) and inserted into soft plant tissues. The two feeding nymphal stages are yellow to orange, cigar-shaped and just visible to the naked eye. Adult males can be distinguished from all other members of the genus by the presence of a comb of stout setae on the posterior margin of the hind femora; also, the ninth abdominal tergite of males bears a pair of long curved dark lateral processes (drepanae). Females have the following characters: median ocellar setae on the head arising close together and in line with the anterior margins of the posterior pair of ocelli; forewing posteromarginal cilia wavy not straight; median abdominal sternites fully covered with microtrichia; abdominal tergites and sternites with a transverse anterior dark line; tergites with a dark median area. The larvae are yellow, with the body surface finely granulate.

MEANS OF MOVEMENT AND DISPERSAL

As mentioned above under Biology, the potential of *Scirtothrips* spp. for natural spread is relatively limited. In international trade, S. aurantii could be carried on plants for planting, but in fact interceptions are relatively rare. Unlike many Thysanoptera, *Scirtothrips* spp. seem to require access to soft green tissues, except when pupating in leaf litter and soil. So only seedlings or cuttings with young growing leaf buds are liable to carry these pests. Only young fruits are attacked, so the risk of these thrips being carried on harvested fruits is small. There is no direct evidence that *S. aurantii* has been dispersed beyond its natural range by human activity. It has, however, been intercepted in the Netherlands.

PEST SIGNIFICANCE

Economic impact

At least ten *Scirtothrips* spp. are known as pests of various crops in different parts of the tropics, but most of them have restricted geographic ranges and tropical host plants, such as *S. kenyensis* which damages tea and coffee in eastern Africa, or *S. manihoti* which causes serious leaf distortion of cassava in Central and South America. *Scirtothrips* spp. are particularly associated with plants that are growing actively in warm, dry conditions; they are usually more abundant on terminal shoots rather than within the canopy of a tree. With *S. citri* and *S. dorsalis* (EPPO/CABI, 1996), *S. aurantii* is, as a pest of citrus, one of the most important *Scirtothrips* spp. for international agriculture.

In South Africa and Zimbabwe, *S. aurantii* causes reduction in citrus yields through serious damage to young leaves, and reduces the proportion of export quality fruits. It is a most serious pest at low altitudes (Hill, 1983). It is not generally regarded as harmful to crops further north in Africa, although this might be due to less intensive cultivation practices. Damage to tea plants has been reported from plantations in Malawi (Rattan 1992), and *S. aurantii* is the primary cause of banana fruit spotting in Yemen (Nasseh & Mughni, 1990).

Control

It is recommended, for example, to spray fruits towards the end of a main flowering period, when three-quarters of petals have fallen, using a water solution of lime sulphur (Hill, 1983). Triazophos is currently used in South Africa, and yellow card traps and treatment thresholds are used to time treatments (Samways *et al*., 1987; Grout & Richards, 1990b). Nasseh & Mughni (1990) refer to the use of dimethoate and natural insecticides in Yemen. Rattan (1992), for control of the pest on tea in Malawi, notes that dimethoate is to be preferred to fenitrothion or malathion, that quinalphos, triazophos and acephate are also effective, and that resistance has developed to the synthetic pyrethroids. Predacious mites such as *Euseius addoensis*, persisting on surrounding shade trees, may contribute to control in South Africa (Grout & Richards, 1992).

Phytosanitary risk

S. aurantii has recently been added to the EPPO A1 list, and is also a quarantine pest for APPPC, OIRSA and SPC. Its occurrence in citrus-growing areas with a subtropical or Mediterranean climate suggests that it could probably establish on citrus in southern Europe and the Mediterranean area. It is a damaging pest on citrus, and requires insecticide treatments. Its potential effect on other hosts in the EPPO region does not merit any particular concern.

PHYTOSANITARY MEASURES

Importation of *Citrus* plants for planting from countries where *S. aurantii* occurs should be prohibited or restricted, as it is in general already on account of other important pests.

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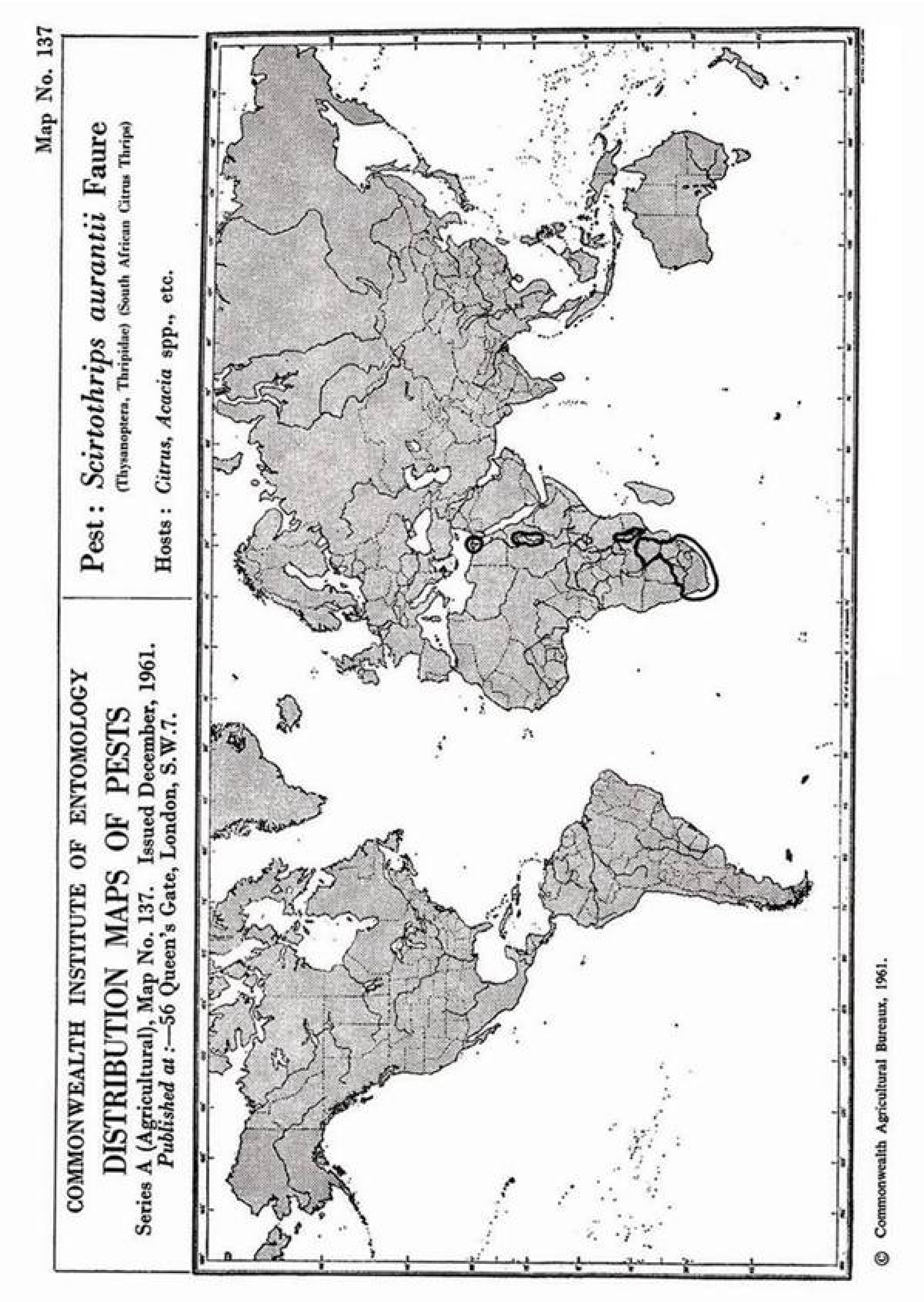
Source

European and Mediterranean Plant Protection Organization (EPPO) data sheets on quarantine pests

Available online at:
http://www.eppo.org/QUARANTINE/insects/Scirtothrips_aurantii/SCITAU_ds.pdf

Distribution map for *Scirtothrips aurantii*



Source

Commonwealth Institute of Entomology (1961) *Distribution Maps of Pests*, *Series A* No. 137. CAB International, Wallingford. UK.

Thrips
South African Citrus Thrips
Scirtothrips aurantii Faure Thysanoptera, Terebrantia, Thripidae, Thripinae

Status
Exotic (established in Australia) High Impact Pest Species

Dorsal view

Caption: Adult female
Source: Laurence Mound ANIC, CSIRO

Female mainly yellow, antecostal ridges of tergites and sternites dark brown with small brown area; antennal segment I white, II–III grey, V–VIII brown; forewings pale with clavus shaded. Antennae 8-segmented. Head with closely spaced transverse sculpture lines in postocular region and ocellar triangle; ocellar setae pair III close together between anterior margins of hind ocelli. Pronotum with closely spaced transverse sculpture lines; posterior margin with 4 pairs of setae, setae B2 about 30 microns long. Metanotum with irregular longitudinal reticulations on posterior half, median setae close to anterior margin. Forewing first vein with 3 setae on distal half, second vein with 3 widely spaced setae; posterior fringe cilia wavy. Tergites III–VI with median setae small but close together; II–VIII with lateral thirds bearing closely spaced rows of fine microtrichia and 3 discal setae; VIII with complete comb, discal microtrichia extending medially; IX with no discal microtrichia. Sternites covered with rows of microtrichia.
Male similar to female but smaller; tergite IX posterior angles bearing pair of stout curved drepanae extending across tergite X; hind femora with comb-like row of stout setae.

Specimen contact point: Laurence Mound

Citation: Mound, L. (2007) South African Citrus Thrips *(Scirtothrips aurantii)* Pest and Diseases Image Library. Updated on 23/12/2007 11:11:51 AM.

Available online: http://www.padil.gov.au/viewPestDiagnosticImages.aspx?id=188

Created Date: 28/06/2005 11:19:40 AM

Last Updated: 23/12/2007 11:11:51 AM

European and Mediterranean Plant Protection Organization
Organisation Européenne et Méditerranéenne pour la Protection des Plantes
PM 7/56(1)

Diagnostics[1]
Diagnostic

Scirtothrips aurantii, *Scirtothrips citri*, *Scirtothrips dorsalis*

Specific scope

This standard describes a diagnostic protocol for *Scirtothrips aurantii*, *Scirtothrips citri* and *Scirtothrips dorsalis*.

Specific approval and amendment

Approved in 2004-09.

Introduction

The genus *Scirtothrips* now includes over 100 species (Hoddle & Mound, 2003) throughout the tropics and subtropics, of which several species are of economic importance.

Scirtothrips species go through 5 developmental phases: egg, 2 active larval instars that feed, followed by 2 relatively inactive pupal instars and winged, feeding adults. Eggs are inserted into young and soft tissues of leaves, stems and fruit. The first and second larval stages are found on the green plant parts from which the second stage larvae seek out some sheltered place (leaf litter or crevices of bark) and then pass through two testing stages called propupa and pupa, respectively. Rarely, these occur beneath the calyces of fruits. Winged adults, male and female, are found normally on the green plant parts, where they feed.

Scirtothrips is native to Africa and Yemen and has recently been reported as introduced into Australia (Hoddle & Mound, 2003). Although usually noted as a pest of citrus (especially sweet orange) and sometimes mango, it is actually a very polyphagous species that can be found on more than 50 plant species in a wide range of different plant families, in genera like *Arachis*, *Asparagus*, *Gossypium*, *Musa*, *Ricinus* and *Vitis*. In Yemen, *S. aurantii* is the primary cause of banana fruit spotting.

Scirtothrips citri is a pest of citrus and one of the most important *Scirtothrips* species for international agriculture. It is also a polyphagous species found on more than 50 plant species, in genera such as *Carya*, *Gossypium*, *Magnolia*, *Medicago*, *Phoenix*, *Rosa* and *Vitis*. It occurs in the southern parts of North America (northern parts of Mexico and the states of Arizona, California and Florida in USA).

Scirtothrips dorsalis is known as a pest on many cultivated plants including *Actinidia chinensis*, *Allium cepa*, *Arachis hypogaea*, *Camellia sinensis*, *Capsicum, Citrus*, *Gossypium hirsutum*, *Fragaria*, *Hevea brasiliensis*, *Hydrangea*, *Mangifera*, *Nelumbo*, *Ricinus*, *Rosa*, *Tamarindus indica* and *Vitis vinifera*. In its principal range in tropical Asia, it is mainly a serious pest of vegetables, cotton and roses. Native host plants are probably various *Fabaceae*, such as species of genera *Acacia*, *Brownea*, *Mimosa* and *Saraca*. It is widespread in Asia, northern Australia and the Solomon Islands, Hawaii (USA) and South Africa. *S. dorsalis* is clearly expanding its range at the moment, e.g. Israel (EPPO Reporting Service 2003/084); Saudi Arabia (Laurence Mound, CSIRO, unpublished identification); Côte d'Ivoire (Bournier, 1999).

Identity

Name: *Scirtothrips aurantii* Faure
Synonyms: *Scirtothrips acaciae* Moulton
Taxonomic position: *Insecta: Thysanoptera: Thripidae*
EPPO computer code: SCITAU
Phytosanitary categorization: EPPO A1 list: no. 221, EU Annex designation: II/A1

Name: *Scirtothrips citri* (Mou1ton)
Synonyms: *Euthrips citri* Moulton, *Physothrips citri* (Moulton)
Taxonomic position: *Insecta: Thysanoptera: Thripidae*
EPPO computer code: SCITCI
Phytosanitary categorization: EPPO A1 list: no. 222, EU Annex designation: II/A1

Name: *Scirtothrips dorsalis* Hood
Synonyms: *Heliothrips minutissimus* Bagnall, *Anaphothrips andreae* Karny, *Neophysopus fragariae* Girault, *Scirtothrips dorsalis* var. *padmae* Ramakrishna

[1] The Figures in this Standard marked 'Web Fig.' are published on the EPPO website www.eppo.org.

Taxonomic position: *Insecta: Thysanoptera: Thripidae*
EPPO computer code: SCITDO
Phytosanitary categorization: EPPO A1 list: no. 223, EU Annex designation: II/A1

Detection

All stages of *Scirtothrips aurantii*, *S. citri* and *S. dorsalis* feed on epidermal arid sometimes palisade cells of young leaves, and on the apex of young fruits especially when concealed under the calyx. They do not feed on mature leaves. They could be carried on plants for planting, in particular seedlings or cuttings with young growing leaf buds, and these should be examined carefully. Only young fruits are attacked, so the risk that this species is carried on harvested fruits is low. Symptoms are: silvering of the leaf surface; linear thickenings of the leaf lamina: brown frass markings on the leaves and fruits; grey to black markings on fruits often forming a conspicuous ring of scarred tissue around the apex (Web Fig. 1); ultimately fruit distortion and early senescence of leaves. For *S. citri*, examination of leaves is less useful because larvae are almost exclusively localized on young growing buds, young leaves, sepals and young fruits, so these should be examined particularly carefully. Considering the small size of this insect, direct visual search is insufficient. The electric Berlese method should be used.

For *S. citri*, confusion of symptoms with those caused by other pests and diseases is not very probable. For example, the fungus *Septoria citri* also causes spots on fruits, but the presence of pycnidia can avoid any confusion. Some mites can cause spots on fruits, but without the shape of a ring.

In *S. aurantii*, eggs are bean-shaped, minute (less than 0.2 mm). The two feeding larval stages are yellow to orange, cigar-shaped and just visible to the naked eye. The adult thrips is reddish-orange, less than 1 mm long. The two feeding larval stages of *S. citri* are yellow to orange, cigar-shaped and just visible to the naked eye.

Identification

Members of the genus *Scirtothrips* are readily distinguished from all other *Thripidae* by the following characters:

- surface of pronotum covered with many closely spaced transverse striae (Web Fig. 2d)
- abdominal tergites laterally with numerous parallel rows of tiny microtrichia (Web Fig. 2c)
- sternites with marginal setae arising at posterior margin
- metanotum with median pair of setae arising near anterior margin (Web Fig. 2e).

A species closely related to *Scirtothrips* is *Drepanothrips reuteri*, a native European pest of grapevine, but this species has antennae with 6 segments (the 3 terminal segments being fused), whereas *Scirtothrips* has 8-segmented antennae.

Of about 100 species described in *Scirtothrips*, most were defined originally by their authors on the basis of unreliable or minor characters such as colour and silhouette. The legitimacy of 32 species recently described from Mexico (Johansen & Mojica-Guzman, 1999) has been strongly challenged (Mound & zur Strassen, 2001). Mound & Palmer (1981) describe many structural details by which *Scirtothrips* spp. may be distinguished. Although not reliable in itself, natural coloration can help to distinguish species and it is useful to have some uncleared specimens showing the natural coloration. For storage, specimens should be transferred to 60% ethyl alcohol and kept in the dark, preferably at temperatures well below 0°C to prevent loss of colour.

Identification of *Scirtothrips* is based on male or female adults, both of which are winged. They are pale and minute, and cleared specimens on microscopic slides are needed for identification. A magnification factor between 100 and 600 is necessary. Characters that allow identification down to the genus *Scirtothrips* are shown in Table 1.

Five *Scirtothrips* spp. are native to Europe and the Mediterranean area: *S. mangiferae* Priesner (Egypt, Israel), characterized by its dark wings, *S. inermis* Priesner (Italy,

Table 1 Key for the identification of adults of the genus *Scirtothrips*

Abdominal segment X usually conical, not tubular; serrated ovipositor present; wing surface with microtrichia	*Terebrantia*	
Ovipositor downturned at the apex; abdominal sternite VIII not developed; sense cones on antennal segments III and IV emergent, each more than twice as long as wide (Mound & Marullo, 1996: p. 41)	*Thripidae*	Web Fig. 2(a) Web Fig. 2(b)
Head and legs not strongly reticulately sculptured, abdominal tergites may be laterally sculptured; antennal segments III and IV usually with microthrichia; terminal antennal segments rarely elongate; meso- and/or metathoracic furcae with or without spinula; forewing first vein not fused to costa	*Thripinae*	
Abdominal tergites covered with numerous microtrichia	*Scirtothrips*	Web Fig. 2(c)
Body often clear yellow		
8 antennal segments		Web Fig. 2(b)
3 ocellar setae		Web Fig. 2(d)
Posteromarginal pronotal setae B2 usually elongate		Web Fig. 2(d)
Pronotum transversely striate, regular without dark internal apodeme		Web Fig. 2(d)

Portugal (Açores, mainland), Spain (Islas Canarias, mainland)), *S. canizoi* Titschack (Spain), *S. dignus* zur Strassen (Spain, Greece) and *S. bournieri* Berzosa & Caño (Spain) (Berzosa & Caño, 1990). *S. longipennis* (Bagnall) is an introduced species, occurring in glasshouses but not common. *S. inermis* is an important pest in citrus culture in Spain (Lacasa *et al*., 1996). At present, there is no key to separate all these species from *S. aurantii*, *S dorsalis* and *S. citri*. The European species (except for *S. bournieri*) can be identified with zur Strassen (1986). For several economically important *Scirtothrips* spp., the separation to species is based on well defined characters (Table 2). A key to the economic species was published by Mound & Palmer (1981). In addition, Nakahara (1997) described a new pest species on avocado from USA (California), *Scirtothrips perseae*, and Hoddle & Mound (2003) published a key to Australian species, including several newly described species.

Identification of *Scirtothrips* species in the larval stage is impossible; there is no suitable identification key. Miyazaki & Kudo (1986) described characteristics of the second stage larva of *S. dorsalis*, but similar descriptions for other species within this genus are not available.

Table 2 Taxonomic characteristics of economically important *Scirtothrips* species (after Mound & Palmer (1981), Table (1)

	Characteristics								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
S. aurantii	**+**	**+**	**+**	**B**	**2**	**4**	**30**	**A**	**4**
S. citri	**-**	**-**	**-**	**C**	**2**	**4**	**55**	**B**	**4(3)**
S. dorsalis	**+**	**+**	**+**	**A**	**2**	**4**	**25-30**	**B**	**4**
S. inermis	-	+	+	A	2	4	65	B	4
S. longipennis	-	+	+	D	2	4	30	B	3
S. mangiferae	-	-	-	B	2	4	25	A	4
S. oligochaetus	-	-	+	A	2	4	25-30	B	4

	10	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
S. aurantii	**2-5**	**+**	**3**	**+**	**-**	**C**	**+**	**+**	**Af**
S. citri	**3**	**+**	**5**	**+**	**+**	**A**	**-**	**-**	**NA**
S. dorsalis	**2**	**-**	**3**	**+**	**+**	**C**	**-**	**-**	**P,O,A**
S. inermis	2	-	5	+	+	B	-	-	P,NA,A
S. longipennis	3	+	3	-	+	A	?	-	P,NA,A
S. mangiferae	3(4)	+	4-6	+	+	B	+	-	P,Af
S. oligochaetus	2	-	4-5	+	+	C	-	-	SA,Af,O

Legend of characteristics (after Mound & Palmer (1981), Table (1): (1) Abdominal tergites with dark median area; (2) Tergal antecostal ridge dark; (3) Sternal antecostal ridge dark; (4) Ocellar setae pair III position. A: between hind ocelli; B: in front of hind ocelli; C: behind fore ocellus; (5) Number of major postocu1ar setae medially; (6) Number of pronotal posteromarginal setae; (7) Length of pronotal B2 setae (in µm approximately); (8) Metanotal median setae position. A: at anterior margin, B: just behind anterior margin; (9) Number of anteromarginal setae on forewing scale; (10) Number of second vein setae on forewing; (11) Forewing cilia wavy (+) or straight (-); (12) Number of setae on tergal microtrichial fields; (13) Microtrichia present anteromedially on tergite VIII; (14) Microtrichia present medially on tergite IX; (15) Distribution of microtrichia on sternites. A: segment covered laterally for 1/3rd, B: segment covered laterally for 2/3rd, C: completely covered; (16) Drepanae present on tergite IX of male; (17) A comb of stout setae on posterior margin of hind femora of male; (18) Distribution - P: Palaearctic, O: Oriental, A: Australian, Af: afrotropical, NA: North America, SA: South America.

Specimens detected in imported consignments, or collected in the field, can be preserved in 70% ethyl alcohol for 24-48 h. If intended for preparing permanent microscope slides, they should be preserved in AGA, a mixture of 9 parts 60% ethyl alcohol, 1 part glycerine and 1 part acetic acid, and sent to a specialist. Cleared adult specimens mounted on microscope slides are necessary for identification.

There are several methods for mounting thrips (the complete methodology is described by Palmer *et al*., 1989):

- Temporary mounts: direct observation in lactic acid, or Heinz solution, after slight heating. Advantage: can be examined directly. Disadvantage: crushing of the body and possibly deformation of some appendices.
- Semi-temporary mounts: in Faure solution. Advantage: satisfactory clearing without handling, no deformations. Disadvantage: obligatory sealing, conservation only a few months.
- Permanent mounts: in Canada balsam. Advantage: conservation for reference collection with or without maceration. Disadvantage: method is long and difficult to use.

The specimens should preferably be compared with reference material of the species, identified by a specialist. It may be necessary to consult a specialist in *Thysanoptera*.

Description of *Scirtothrips aurantii*

Female (after Palmer *et al*., 1989): ocellar setae III situated on a line with anterior margins of posterior ocelli (Web Fig. 3a); median metanotal setae situated at anterior margin (Web Fig. 3b); tergites with median dark patch; tergites and sternites with dark antecostal ridge; tergites laterally with 3 setae on microtrichia fields (Web Fig. 3c); forewing hind vein with 2-5 setae, fringe cilia wavy; tergite VIII with microtrichia present medially, absent on IX; sternites completely spanned by microtrichia.

Adult males can be distinguished from all other members of the genus by the presence of a comb of stout setae on the posterior margin of the hind femora; also the abdominal tergite IX bears a pair of long curved dark lateral processes (drepanae) (Web Fig. 3c).

Description of *Scirtothrips citri*

Female and male (after Palmer *et al*., 1989): ocellar setae III situated within ocellar triangle near posterior margin of first ocellus (Web Fig. 4a); median metanotal setae situated behind anterior margin (Web Fig. 4b); hind vein of the forewing with three setae, fringe cilia wavy; tergites and sternites completely pale, without dark antecostal ridges; tergites laterally with five setae on microtrichia fields; tergites VIII and IX with microtrichia medially; sternites with microtrichia only between posteromarginal setae b2 and b3.

Unlike *S. aurantii*, the male of *S. citri* does not have a pair of dark lateral processes (drepanae) on the ninth abdominal tergite.

Description of *Scirtothrips dorsalis*

Female and male (after Palmer *et al*., 1989): ocellar setae III situated between posterior margin ocelli (Web Fig. 2d); median metanotal setae situated behind anterior margin (Web Fig. 2e); forewing hind vein with two setae, posterior fringe cilia straight; tergites with dark patch medially; tergites and sternites with dark antecostal ridge; median tergites each with three setae on lateral microtrichial fields (Web Fig. 2c); tergites VIII and IX with microtrichia medially; sternites completely spanned with microtrichia.

Male: unlike *S. aurantii*, tergite IX in males of *S. dorsalis* are without dark lateral drepanae.

Reporting and documentation

Guidance on reporting and documentation is given in EPPO Standard PM7/- (in preparation).

Further information

Further information on these organisms can be obtained from:

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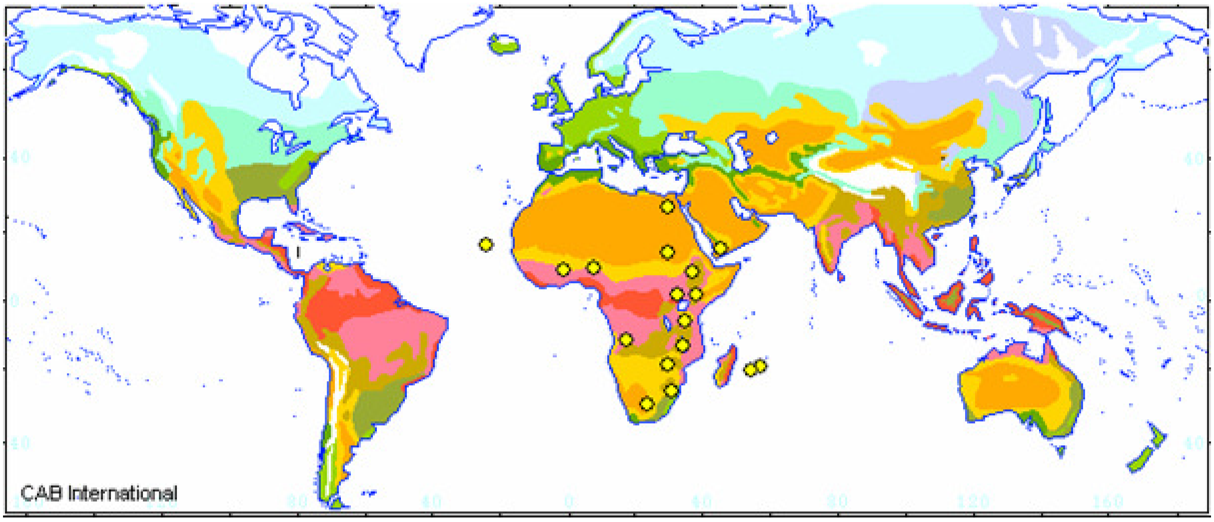
Source

European and Mediterranean Plant Protection Organization (EPPO) standard PM 7/56 (Diagnostic protocol for *Scirtothrips aurantii, Scirtothrips citri, Scirtothrips dorsalis*).

Available online at:
http://archives.eppo.org/EPPOStandards/PM7_DIAGNOS/pm7-56(1)%20SCITSP%20web.pdf

World climate map showing distribution of *Scirtothrips aurantii*



Source
CAB International Crop Protection Compendium

Summary of Information on India's Environment, Economy and Agricultural Products

Environment and economy

India is a country in southern Asia, bordered by the Arabian Sea, the Bay of Bengal, Pakistan, China, Nepal, Bangladesh and Myanmar. It is a large, diverse and populous country that covers an area of 3,166,414 km^2, slightly more than 1/3 the size of the United States, making it the seventh largest country in the world. It is also the second most populous country in the world, with an estimated population of 1.1 billion people in 2005. Approximately 70% of Indians reside in rural areas. India is a liberal democracy, and consists of the union of 28 states and seven federally-governed union territories. The capital is New Delhi, and its largest city is Mumbai (formerly called Bombay). Official languages of India are Hindi and 21 other languages, and English widely spoken and understood.

India's economy is the fourth largest in the world, and is considered to be the second fastest growing large economy. It has the world's third largest gross domestic product (GDP) of US $4.042 trillion, as measured by purchasing power parity. Per capita income is $3,700, ranked at 117th in the world. The country's diverse economy encompasses traditional village farming, modern agriculture, handicrafts, a wide range of modern industries, and a multitude of services. Services are the major source of economic growth, accounting for more than half of India's output with less than one quarter of its labour force. Recent progress has focused on the area of information technology. Major industries include automobiles, cement, chemicals, electronics, food processing, machinery, mining, petroleum, pharmaceuticals, steel, transportation equipment and textiles. In terms of natural resources, India's coal resource is the fourth largest in the world. Sixty percent of the population is employed in agriculture and related industries, which acccounts for 28% of the GDP. Major agricultural crops include rice, wheat, oilseed, cotton, jute, tea, sugarcane and potatoes.

The climate in India ranges from tropical in the south to more temperate in the north, where elevated regions receive sustained winter snowfall. The climate is strongly influenced by the Himalaya mountains and the Thar desert. Its forest cover ranges from the extremes of tropical rainforest to coniferous forest, with moist and dry deciduous forest in between. India also hosts a significant biodiversity, and is home to 7.6% of all mammalian, 12.6% of avian, 6.2% of reptilian and 6.0% of flowering plant species. Major environmental issues include deforestation, soil erosion, overgrazing, desertification and air and water pollution.

Agricultural Products

2004 Crop production statistics

Crop	**Production (x1000 T)**	**Export Value (million USD)**
Lemons and limes	1420.0	2.03
Oranges	3100.0	9.46
Grapefruits and pomelos	142.0	0.33
Groundnuts	7000.0	186.46
Asparagus	0.0	0.00
Tea	850.5	396.48
Guavas, mangoes and mangosteens	10,800.0	101.04
Bananas	16,820.0	18.95
Plantains	0.0	0.00
Grapes	1200.0	25.13

Citrus spp.
Citrus spp. is grown in almost all the states of India. Although the citrus industry in India has faced many challenges, there has been a consistent increase in area and production owing to the awareness for sustained production. Citrus fruits, consisting of mandarin orange (*Citrus reticulata* Blanco), sweet orange [*C. sinensis* (L.) Osbeck] and lime [*C. aurantifolia* Swingle] are grown commercially in tropical, subtropical, arid irrigated and mountainous regions in varying soil and weather conditions. Citrus is grown practically all over India. However the states of Andhra Pradesh, and Maharashtra have the largest share. Although citrus trees on the whole do well in dry climate, with a rainfall between 75 and 125 cm, certain species, such as pummel and certain mandarin oranges, thrive in heavy-rainfall areas of Konkan, Assam and Coorg.

Groundnut (peanut) *Arachis hypogaea* (L.)
Groundnut is the 13th most important food crop of the world. It is the world's 4th most important source of edible oil and 3rd most important source of vegetable protein. Groundnut seeds contain high quality edible oil (50%), easily digestible protein (25%) and carbohydrates (20%).

In India, groundnut is grown on 5.7 million ha with a production of 4.7 million metric tons, with an average productivity of 0.8 metric tons ha -1 during the rainy season and in the post-rainy season it is grown on 0.9 million ha with a production of 1.5 million metric ton, and an average productivity of 1.6 metric tons ha -1.

In Andhra Pradesh, it is grown on 1.6 million ha during the rainy season with a production of 1.6 million tons, and during the post rainy season it is grown on 0.3 million ha with an production of 0.4 million tons. Anantapur district in the state is the largest producer of groundnut with 0.74 million ha of area under cultivation.

Tea
India accounted for 27.4% of world output of tea production in 2004, followed by China (24.6%), Sri Lanka (9.75%), and Kenya (9.4%). Production in India reached 857,000 tonnes in 2003, from 829,000 tonnes in the previous year.

A significant indicator shows India's organic tea production is still on the rise reaching 3,500 tonnes in 2003, with about 75% of it being exported to France, Germany, Japan, the United Kingdom and the United States.

Mangoes
Mangos were brought to England and Europe after the English occupied India in 1800's. Today, India is the world's largest mango producer, growing nearly 1000 varieties of mango and contributing over 50 per cent of the world's total mango production of approximately 23 million metric tons. Hence the mango, *Mangifera indica* L., is the most economically important fruit.

The Indian states with abundant growth of various varieties of mangoes are Andhra Pradesh, Bihar, Goa, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal.

Mango is grown in an area of 1.23 million hectares with an annual production of 10.99 million tonnes, which accounts for 57.18% of the total world production.

Bananas
India is the world's biggest banana grower, with an annual production of 16.8 million tonnes, or over 20 percent of total world output of 72.6 million tonnes in 2005.

But overexploitation and the loss of forests as a result of encroachment and logging, slash-and-burn cultivation and urbanization are causing a rapid loss of wild banana species that have existed in India for thousands of years. Among them are the ancestors of the *Cavendish* variety, the large, pulpy dessert banana which currently accounts for virtually all of world trade, amounting to nearly 20 million tonnes a year.

Cooking bananas and plantains – eaten fried, boiled, baked or chipped – are the staple food of 400 million people in the developing world, while bananas are also used to make fibres and beer. In India, they play an important role in traditional medicine.

Bananas are the world's most exported fruit and the fourth most important food commodity on earth – after rice, wheat and maize – in terms of production value.

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Data Sheet for *Acacia* Species

Acacia is a large genus comprising more than 1000 species belonging to the family Leguminosae, subfamily Mimosoideae. They are distributed in the warm and drier regions of the world mainly in the tropics and subtropics and are more prevalent in Australia and Africa.

Acacia nilotica sub.sp. *indica*

Synonym: *Acacia arabica*

Distribution: Throughout the greater part of India in forest areas, roadsides, farmlands and tank foreshores. It is found all over Tamil Nadu. It is also cultivated. It is either gregarious in patches of forests or in groups or single tree in fields. It grows well in two types of soils i.e. riverian alluvial soil and black cotton soil. The largest tracts are found in Sind. There are three varieties of this babul: Telia babul, Kauria babul and Ramkanta babul.

Uses: Foliage: Tender branches are fodder for goats and sheep. Leaves are good for treatment of diarrhoea. Pods/seeds: Food for goats and sheep. Seeds useful in treating stomach complaints and skin disorders. Bark: Medicinal use in toothache, tannins can be extracted. Wood: Hard, heavy and durable timber useful in house construction, for making agricultural implements, as firewood and for charcoal making. Agroforestry: Often used to demarcate fields.

Propagation: By natural regeneration and seedlings. Seeds from goat and sheep pens are better for artificial sowing than those collected from pods.

Acacia leucophloea Willd.

Distribution: It is widely distributed throughout the greater part of India and in dry deciduous forests. It is not generally planted but occurs in almost all districts of Tamil Nadu.

Uses: Foliage: Rich in proteins and is a good nutritious supplement for animals. Pods: Fodder for animals. Bark: Rich in tannins. It is bitter and acrid and is used in treating diseases of the blood. Bark is boiled with red earth and applied locally on the body to treat heart pain. Also used in curing inflammation, bronchitis and as native medicine in leprotic conditions. Tannins used in preserving hides and skins. Gum: Produces a pleasant smelling vapour on igniting, also used in indigenous medicine. Wood: Timber is hard, strong and tough, used in oil mills, cartwheels and turnery and as splints for cattle in treating bone injury.

Propagation: By natural regeneration.

Acacia farnesiana Willd.

Distribution: This is a native of tropical America. It is cosmopolitan in the tropics and found in the greater part of Indian subcontinent, sometimes growing gregariously in the loose sandy soils of river beds in northern India. Live trees make a good fence. In Tamil Nadu, it is distributed mostly in Chengalpattu, Coimbatore, Dharmapuri, Ramanathapuram, Tiruchirapalli and Tirunelveli districts.

Uses: The plant is one of the ingredients in Sushruta's "Ksharagada", a preparation for the treatment of snakebite. Foliage: Leaves can be used as a substitute for tamarind in chutneys. Leaves are also used for treatment of wounds and ulcers. Bark: It is used in treating stomatitis, itching, bronchitis, leucoderma and ulcers. In the Philippines, stem bark is used for treating prolapsus ani and leucorrhoea. Gum: This is usually marketed with acacia gums. It is sweetish and is used as an aphrodisiac in Ayurveda. It is also useful in confectionary. Flowers: These are fragrant and are the source of the much valued "Cassie" perfume. A mature tree yields about a kg of flower in season from November to March from its 3rd year. Pods: Contain tannins. Wood does not seem to have any use.

Propagation: By natural regeneration and seedling.

Acacia ferruginea **DC**

Distribution: Found in Gujarat, Berar and N. Circars and is fairly common in Deccan, Konkan/Carnatic and the eastern slopes of the Western Ghats. It is scattered in thorny forests. In Tamil Nadu, it is found in the districts of Coimbatore, Kanyakumari, Madurai, Nilgiri, South Arcot, Tirunelveli, Dharmapuri, Salem and Tiruchirapalli.

Uses: Foliage: Leaves used in religious celebrations like Dussera and as fodder for goats and cattle. Used also for treating diseases like diarrhoea, dysentery, gonorrhoea, burns and eye ailments. Bark: Decoction of bark with that of the tamarind tree and a few other trees is used as gargle for sore mouth. Also used in curing itching, leucoderma, ‘kapha’ and ‘vatha’, ulcers and blood diseases. Gum: This is similar to *A. arabica* gum and is used in medicine. It is demulcent, emollient and nutrient. Pods are eaten by goats. Wood: This is very brown and very hard used for agricultural implements and in wooden chariots.

Propagation: By natural regeneration and through seedlings.

Acacia catechu **Willd.**

Distribution: Punjab, Gujarat, Northwestern Himalaya, Central India, Bihar, Konkan and Deccan. It is often seen in Chengalpattu, Coimbatore, Kanyakumari,, Madurai and Nigiri districts in Tamil Nadu.

Uses: Foliage: no reported use. Bark: Used for curing itching, sore throat, bronchitis, indigestion. Flowers: Flowering tops are used in treating gonorrhoea along with cumin, milk and sugar. Wood: Catechu is obtained from heart wood. There are mainly two types: Katha or pale catechu and kutch or dark catechu. They are used in paan preparations, in medicine, in tanning, printing, dyeing and as a preservative. "Kheersal" a white powder or crystalline deposit obtained from catechu wood is used for treatment of cough and sore throat. Timber: This is used as posts in house construction, as rice grinding pestles, oil and sugar cane grinders, ploughs, tent pegs and keels. It is good as a fuel and also for making charcoal of good quality.

Propagation: By natural regeneration and seedlings.

Acacia horrida **(L.F.) Willd.**

Distribution: Deccan and the Carnatic from the Krishna river south, gregarious on poor soils forming extensive forests in places like Guntur, Madurai and Kanyakumari regions. It often grows on bare gravelly soil on the plains and lower hilly slopes helping in preventing erosion and in protecting young plants from animal browsing. Common in southern districts of Tamil Nadu.

Uses: Fruits/pods/seeds: eaten by goats. Bark: used as an adjunct in preparation of arrack. Wood: reddish, very hard, used in agricultural implements, tent pegs and as fuel.

Propagation: By natural regeneration.

Acacia sinuata **(Lour.) Merr.**

Synonym: *Acacia concinna* DC

Distribution: Throughout India but more common in Deccan. In Tamil Nadu it is commonly seen in Chengalpattu, Coimbatore, Nilgiris, Tirunelveli, Dharmapuri, Salem and Tiruchirapalli districts.

Uses: Foliage: Tender leaves are acidic and are used sometimes in chutneys and also in ayurvedic preparations. Bark: Contains tannins and is sometimes used for tanning fishing lines. Pods: They are used as a substitute for soap. Shikakai is preferred to synthetic soap for washing hair. A bush can yield 20-30 kg of pods per year. Pods are also used for treating skin ailments. Seeds fed to chicken are supposed to prevent diseases.

Propagation: By natural regeneration, seedling

Acacia pennata Willd

Distribution: Throughout India, common in Central and Eastern Himalaya, Bihar and the Western peninsula in moderately dry forests. It ascends up to 5000 feet on the hills in ravines and along streams. It is well distributed in most districts of Tamil Nadu.

Uses: Foliage: Leaf juice mixed with milk is used for treatment of indigestion in infants. Also used for scalding of urine and for curing bleeding gums. Bark: This has medicinal use for treatment of diseases of the blood, bronchitis, asthma and for stomach complaints. Bark tannins used for tanning fishing nets in Maharashtra.

Propagation: By natural regeneration.

Acacia senegal Willd

Distribution: Mainly in Punjab and Rajasthan and dry rocky hills of Sind, south-east Punjab, northern Aravalli hills and other parts of Rajasthan It can survive under most adverse conditions. Found in Tamil Nadu also.

Uses: Foliage: Browsed by camels and goats. Bark: Yields a gum used in medicine and confectionary. Also used for making mucilage. Wood: Heartwood is nearly black and is used for making weavers shuttle. It is a good fuel wood.

Propagation: By natural regeneration.

Acacia modesta Wall

Distribution: It is gregarious in sub-Himalayan tracts and the outer Himalaya from Jammu eastwards, ascending up to 4000 feet. There is large depletion of this species due to exploitation for firewood. Large trees have mostly disappeared except in cultivated lands and around villages. Not seen in Tamil Nadu.

Uses: Foliage: Tender twigs are used for cleaning teeth in Punjab. Bark: A gum can be obtained from the bark in small quantities which is translucent and pale yellow and is used in medicine. Wood: It is strong and extremely hard used in cane crushers, cart wheels, agricultural implements and as fuel.

Propagation: By natural regeneration.

Source
Madras Naturalists' Society Blackbuck. Excerpts from
http://www.blackbuck.org/blackbuck/vol_15_1/article5.htm

Thrips (Thysanoptera) species associated with mango trees in South Africa

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Thrips (Thysanoptera) were collected on mango trees (*Mangifera indica* L. (Anacardiaceae)) from 1992-1996 in the main mango production areas in South Africa to identify the complex of species associated with this crop and to monitor their abundance. Different monitoring techniques were used, which included sampling of flowers, fruit and leaves and the use of both yellow card and dispersal/emergence trapping methods. Fifteen thrips species were recorded, eleven belonging to the family Thripidae and four to the family Phlaeothripidae. The citrus thrips, *Scirtothrips aurantii* Faure, and the red-banded thrips, *Selenothrips rubrocinctus* (Giard), were the only two species that caused lesions on the fruit. Numbers of *S. rubrocinctus* were usually low in mango orchards and did not seem to be of economic importance. By contrast, *Scirtothrips aurantii* was abundant on new growth, causing stunting of growth and leaf malformation. *Aleurodothrips fasciapennis* (Franklin) and *Haplothrips bedfordi* Jacot-Guillarmod were the only predatory thrips recorded. The western flower thrips, *Frankliniella occidentalis* (Pergande), was collected from mango flowers in the Letsitele area, while *Thrips acaciae* Trybom, *Thrips tenellus* Trybom and *S. aurantii* were the most abundant species in the flowers.

Key words: Thysanoptera, *Mangifera indica*, *Scirtothrips aurantii*, *Selenothrips rubrocinctus*, mango, thrips.

INTRODUCTION

Different species of Thysanoptera vary greatly in their habits. Most feed, using their piercing and sucking mouthparts, on either flowers and leaves of green plants, or fungi, while some are predatory and a few feed on mosses and detritus (Lewis 1997b). Flowers are particularly favoured by many species (Kirk 1984, 1987). Thrips can damage crops directly by feeding or indirectly by virus transmission (Ullman *et al*. 1997). Predatory thrips can be useful as natural biocontrol agents, feeding on pest insects and mites, and thrips in flowers can be useful as pollinators by increasing crop yield (Kirk 1997).

Several thrips species are known to attack cultivated mangoes (*Mangifera indica* L. (Anacardiaceae)) worldwide. The greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché), is a cosmopolitan species which is known to occur on this crop in Israel (Wysoki *et al*. 1993). The red banded or cacao thrips, *Selenothrips rubrocinctus* (Giard), is also a cosmopolitan species that attacks mango in several countries (Hill 1975; Lewis 1997a). Both *H. haemorrhoidalis* and *S. rubrocinctus* are sporadic, but potentially serious, pests on avocado fruit in South Africa (Dennill & Erasmus 1992). *Scirtothrips rubrocinctus* usually damages young mango trees and trees in nurseries, but rarely mature trees (Hill 1975). The extent of damage caused by these two species to mango in South Africa is not known.

The South African citrus thrips, *Scirtothrips aurantii* Faure, has been known to severely scar young mango fruit (Annecke & Moran 1982). The chilli thrips, *Scirtothrips dorsalis* Hood, and the grapevine thrips, *Rhipiphorothrips cruentatus* Hood, occur on mango in South Asia and cause leaf damage (Lewis 1997a). *Scirtothrips dorsalis* has been recorded from the castor oil plant, *Ricinus commnunis* L., in South Africa (Gilbert 1986), but has not yet been recorded as a crop pest in South Africa. The Mediterranean mango thrips, *Scirtothrips mangiferae* Priesner, attacks mango in Egypt and Israel (Mound & Palmer 1981; Venezian & Ben-Dov 1982; Wysoki *et al*. 1993). This species can be a severe pest on mainly young trees, causing the young leaves to curl and drop prematurely. Twigs of infested shoots are much shorter than those of uninfested ones. The western flower thrips, *Frankliniella occidentalis* (Pergande), is an economically important pest of mango in Israel and causes serious damage consisting of skin silvering and heavy skin

African Entomology **9**(2): 153-162 (2001)

cracking (Ben-Dov *et al.* 1992; Wysoki *et al.* 1993). *F. occidentalis* was first documented in South Africa in 1987 and possibly entered the country on cut flowers imported from Europe (Giliomee 1989), but has not previously been recorded from mango in South Africa. The castor thrips, *Retithrips syriacus* (Mayet), is listed on mango in Israel, but is not considered to be of economic importance (Wysoki *et al.* 1993). This species is known in South Africa from *Combretum zeyheri* Sonder (Zur Strassen 1960). *Thrips hawaiiensis* (Morgan) occurs on mango in Thailand (Lee & Wen 1982), while *Haplothrips tenuipennis* Bagnall and *Thrips palmi* Karny cause damage to mango flowers in South Asia (Lewis 1997a).

The objective of this study was thus to identify the Thysanoptera associated with mango trees in South Africa and to make observations on the abundance and importance of the different species.

MATERIAL AND METHODS

Thrips survey

Thrips occurring on mango leaves, flowers and fruit were collected from 1992 to 1996 in different production areas of Mpumalanga (Friedenheim (25°27'S 30°58'E), Kaapmuiden (25°26'S 31°30'E), Malelane (25°30'S, 31°14'E), Nelspruit (25°26'S 30°58'E)) and the Northern Province (Hoedspruit (24°30'S 31°10'E), Letsitele (23°48'S 30°25'E), Nondweni (23°05'S, 30°58'E)). Leaves, flowers and fruit were examined and any thrips present were removed with a fine brush. Inflorescences were also shaken over a tray and the thrips collected using an aspirator. The thrips were stored in a mixture of nine parts 60 % ethyl alcohol and one part acetic acid.

Monitoring thrips in the flowers and on young fruit

To determine the diversity of thrips found in mango flowers, flowers were sampled from budding (August 1995) until the average fruit length was 71 mm. This was done in a mango orchard at the Institute for Tropical and Subtropical Crops (ITSC) Nelspruit Experimental Farm (25°26'S 30°58'E). This orchard consisted of selected open-pollinated seedlings (the origin of the pollen unknown). Inflorescences at the same stage of development were marked and sampled weekly by shaking five inflorescences over a tray and collecting thrips with an aspirator. This was ITSC Friedenheim Experimental Farm (25°27'S, 30°58'E) during 1996. In this case, ten inflorescences were sampled from each cultivar. Sampling commenced on 12 August 1996 and was terminated on 7 October 1996 when the average length of the Zill fruit was 9 mm and the Sensation fruit was 19 mm.

Monitoring thrips with yellow card traps

In a Sensation orchard at the ITSC Nelspruit Experimental Farm, three non-fluorescent yellow polyvinyl chloride traps (140 × 76 × 0.2 mm) were used for the monitoring of adult thrips from August 1992 until March 1993. Traps were also placed in a Zill orchard and a Fascell orchard at the ITSC Friedenheim Experimental Farm from August to November 1992. From September to November 1996 traps were placed in a Zill and Sensation orchard on the ITSC Friedenheim Experimental Farm. Both sides of the traps were coated with a sticky adhesive, Fly-tac®. Traps were suspended 1.5 m to 2 m above the ground on the northern side of the tree. The traps were placed along a diagonal across the orchard with one trap in the centre and the other two traps near the opposing corners. Every week, traps were removed and replaced. Removed traps were covered with clear polyethylene plastic wrap. Thrips were counted using a stereo-microscope.

Monitoring thrips with dispersal/emergence traps

Dispersal/emergence (D/E) traps sample mature thrips larvae as they drop to the ground to pupate, as well as adults emerging from the soil. Each trap consisted of a square glass plate (250 × 250 × 3 mm) placed on top of a polyvinyl chloride irrigation pipe with a diameter of 130 mm and a height of 100 mm. The glass plate was covered with a sticky adhesive, Fly-tac®, and served as the trapping surface. Larger D/E traps were used by Reed & Rich (1975) and Tanigoshi & Moreno (1981) for monitoring *Scirtothrips citri* (Moulton) in citrus orchards in the U.S.A. and Gilbert (1992) for monitoring *S. aurantii* in South African citrus orchards. These traps were used for monitoring *S. aurantii* and other thrips in a Zill and Sensation orchard at the ITSC Friedenheim Experimental Farm from 26 August to 4 November 1996. Three traps per orchard were used and placed 300 mm from the tree trunks (Reed & Rich 1975; Gilbert 1992). Traps were placed on the northern side. As the traps prevented the larvae from reaching the ground, it was necessary to change the position to

Table 1. Species of thrips collected on mango flowers, leaves and fruit at several localities in South Africa.

Species	Localities
Flowers	
Suborder Tubulifera	
Haplothrips bedfordi Jacot-Guillarmod (Phlaeothripidae)	Friedenheim, Kaapmuiden, Nelspruit, Nondweni
Haplothrips clarisetis Priesner (Phlaeothripidae)	Friedenheim, Kaapmuiden, Letsitele, Nelspruit, Malelane
Haplothrips gowdeyi (Franklin) (Phlaeothripidae)	Friedenheim, Hoedspruit, Kaapmuiden, Nelspruit
Suborder Terebrantia	
Florithrips dilutus (Hood) (Thripidae)	Letsitele
Frankliniella occidentalis (Pergande) (Thripidae)	Letsitele
Frankliniella schultzei (Trybom) (Thripidae)	Friedenheim, Kaapmuiden, Letsitele, Nelspruit,
Hydatothrips adolfifriderici (Karny) (Thripidae)	Nelspruit
Megalurothrips sjostedti (Trybom) (Thripidae)	Friedenheim, Hoedspruit, Kaapmuiden, Nelspruit
Ramaswamiahiella subnudula Karny (Thripidae)	Hoedspruit, Letsitele, Nelspruit
Scirtothrips aurantii Faure (Thripidae)	Friedenheim, Hoedspruit, Kaapmuiden, Letsitele, Malelane, Nelspruit, Nondweni
Taeniothrips gowdeyi (Bagnall) (Thripidae)	Kaapmuiden, Hoedspruit, Letsitele
Thrips acaciae Trybom (Thripidae)	Friedenheim, Nelspruit
Thrips tenellus Trybom (Thripidae)	Friedenheim, Hoedspruit, Kaapmuiden, Letsitele, Malelane, Nelspruit, Nondweni
Leaves	
Suborder Tubulifera	
Aleurodothrips fasciapennis Franklin (Phlaeothripidae)	Friedenheim, Nelspruit
Haplothrips bedfordi Jacot-Guillarmod (Phlaeothripidae)	Friedenheim, Kaapmuiden, Letsitele, Nelspruit
Haplothrips clarisetis Priesner (Phlaeothripidae)	Letsitele
Suborder Terebrantia	
Scirtothrips aurantii Faure (Thripidae)	Friedenheim, Hoedspruit, Kaapmuiden, Letsitele, Malelane, Nelspruit
Selenothrips rubocinctus (Giard) (Thripidae)	Nondweni, Friedenheim, Nelspruit
Fruit	
Suborder Tubulifera	
Haplothrips bedfordi Jacot-Guillarmod (Phlaeothripidae)	Friedenheim, Nelspruit
Suborder Terebrantia	
Scirtothrips aurantii Faure (Thripidae)	Friedenheim, Hoedspruit, Kaapmuiden, Letsitele, Malelane, Nelspruit
Selenothrips rubocinctus (Giard) (Thripidae)	Friedenheim, Nondweni, Hoedspruit, Nelspruit

enable the continued monitoring of emerging adults. Glass plates were removed weekly and replaced with new ones. The removed plates were covered with clear polyethylene plastic wrap and taken to the laboratory for evaluation. As it is difficult to distinguish between the larvae of the different species, only the adults were counted on both sides of the glass plate.

RESULTS AND DISCUSSION

Thrips survey

Thirteen species were identified from the flowers, five from the leaves and three from the fruit (Table 1).

Haplothrips bedfordi Jacot-Guillarmod, a predatory thrips, occurred on flowers, leaves and fruit and was collected at five sites (Table 1). *Haplothrips bedfordi* was found in association with *S. aurantii* on the fruit. This species is a predator of *S. aurantii* on citrus, where both larvae and adults feed on *S. aurantii* (Bedford 1943). *Haplothrips clarisetis* Priesner occurred on the flowers and leaves (Table 1). *Haplothrips gowdeyi* (Franklin) was collected from the flowers at four localities (Table 1). *Haplothrips clarisetis* and *H. gowdeyi* are known plant feeders and appear on a wide range of host plants (Zur Strassen 1960; Gilbert 1990).

Florithrips dilutus (Hood) was only collected from the flowers at one locality (Table 1).

Frankliniella occidentalis was collected for the first time on mango flowers in this study (Table 1). Although found at Letsitele, this species may expand its range as it was introduced during the 1980s (Giliomee 1989). This species is highly polyphagous, having been recorded on numerous hosts (Brodsgaard 1989; Mound 1997). In Israel, where serious damage is inflicted on mango fruit, very large numbers of *F. occidentalis* were present on the inflorescences (Ben-Dov *et al.* 1992; Wysoki *et al.* 1993). Such numbers have never been observed in South Africa and it remains to be seen whether or not this species can inflict the levels of damage observed in Israel.

Frankliniella schultzei (Trybom), known as the common flower thrips, occurred at four localities (Table 1). This polyphagous and flower-living species has a worldwide distribution and can damage young leaves within the bud (Mound 1997). It is known to carry spores of mildews, moulds and rusts from infected plants and is also a vector of tomato spotted wilt virus (Ullman *et al.* 1997). *Frankliniella schultzei* also occurs in citrus flowers in South Africa but does not cause damage (M.J. Gilbert, pers. comm.).

Hydatothrips adolfifriderici (Karny) was only collected on one occasion (Table 1). It is known to occur on a wide range of host plants, including legumes (Zur Strassen 1960; Mound 1997). *Megalurothrips sjostedti* (Trybom) was collected from mango flowers at four localities (Table 1). This species is known as the bean thrips in Africa and is a major pest of cowpeas, where mechanical damage to flowers may result in yield loss (Alghali 1992). *Ramaswamiahiella subnudula* Karny was collected from flowers at three localities (Table 1).

Scirtothrips aurantii was collected from the flowers, leaves and fruit and occurred at all collecting sites (Table 1). This species was only collected from new leaves and young fruit and it seemed that feeding did not take place on mature leaves and fruit. Both adults and larvae were observed to cause lesions on the fruit, leaf malformation and stunting of new growth. The lesions on the fruit consisted of silvering and cracking of the skin. The damage on the fruit was only cosmetic and no harm was done to the fruit flesh. Mango fruit with large lesions are not suitable for export. According to the export standards of the South African Mango Growers' Association, lesions larger than 400 mm^2 for count 7-14 and 500 mm^2 for count 4-6 fruit are not acceptable for export. Criteria for the local market are not as strict, but appearance of the fruit affects its marketability. This species appeared to be the most economically important thrips species on mango and is also a well documented pest on citrus in South Africa (Gilbert & Bedford 1998).

Selenothrips rubrocinctus fed on both young and mature leaves and fruit but was not found in the flowers (Table 1). Characteristically associated with feeding damage on the fruit and leaves were numerous small, shiny black spots of excreta. *Selenothrips rubrocinctus* fed on both sides of the leaves and caused rust-coloured feeding scars as well as curled leaf edges. Greyish lesions were caused on the mango fruit. Although *S. rubrocinctus* can become a severe pest in young mango plantings (Hill 1975), numbers in the orchards were usually low and seemed to be under good biological control. The phytoseiid mites, *Euseius* sp. nr. *rhusi*, *Iphiseius degenerans* (Berlese), *Typhlodromus vescus* Van der Merwe and *Euseius citri* (Van der Merwe & Ryke) were found in association with *S. rubrocinctus* and seemed to regulate thrips numbers.

Taeniothrips gowdeyi (Bagnall) was found in inflorescences at three sites (Table 1). It occurs commonly within citrus flowers but its numbers are low compared to *Thrips tenellus* Trybom (Gilbert 1990). *Thrips acaciae* Trybom was collected from flowers at two localities (Table 1) and is also known to occur in the flowers of *Acacia karroo* (Zur Strassen 1960). *Thrips tenellus* was common in the mango flowers and occurred at all the collecting sites (Table 1). It is also commonly found in citrus flowers and in the flowers of *Acacia* spp. (Gilbert 1990). Both *T. acaciae* and *T. tenellus* probably feed on pollen. Very high numbers of *Thrips* spp. were observed in the flowers, but fruit abortion and yield loss did not seem to be affected.

Aleurodothrips fasciapennis (Franklin), which was collected from the leaves at two localities (Table 1), is a predatory thrips that feeds on scale insects (Palmer & Mound 1989). This species is known to prey on the mango scale *Aulacaspis tubercularis* Newstead in South Africa (Labuschagne 1993).

Apart from thrips, there was a large complex of other insects and mites present in the flowers. The most noteworthy of these were *Orius* spp. (Anthocoridae), which were commonly found preying on thrips in the flowers.

Many species of thrips are known to transmit fungi on their bodies by contact and movement.

Table 2. Thrips species collected at weekly intervals from mango flowers in a open-pollinated seedling orchard at Nelspruit.

Date Status of flowers/fruit	Species (number collected)
1995-08-14 All flowers on panicle closed	*H. gowdeyi* (2). *Haplothrips* sp. (2), *S. aurantii* (24), larvae (3)
1995-08-2 1 15 % of flowers on panicle open	*H. gowdeyi* (14), *S. aurantii* (1), larvae (1)
1995-08-28 85 % of flowers on panicle open	*H. clarisetis* (10), *F schultzei* (6), *S. aurantii* (14), *T. tenellus* (5) larvae (2)
1995-09-04 100 % of flowers on panicle open	*H. gowdeyi* (2), *S. aurantii* (14), *T. tenellus* (4)
1995-09-11 Small fruit setting	*S. aurantii* (10), *T. tenellus* (8), larvae (15)
1995-09-18 Average fruit length 3 mm	*H. bedfordi* (2), *H. gowdeyi* (2), *S. aurantii* (14), *T. tenellus* (4)
1995-09-26 Average fruit length 9 mm	*S. aurantii* (18), larvae (3)
1995-10-02 Average fruit length 12 mm	*S. aurantii* (34), larvae (12)
1995-10-09 Average fruit length 22 mm	*S. aurantii* (20), larvae (16)
1995-10-16 Average fruit length 39 mm	*S. aurantii* (1)
1995-10-23 Average fruit length 58 mm	*S. aurantii* (1), larvae (1)
1995-10-30 Average fruit length 58 mm	-
1995-11-06 Average fruit length 71 mm	-

Fungal diseases are present on mangoes in South Africa (Manicom 1998), but thrips are not considered to be particularly important as vectors of pathogens relative to dissemination occurring by wind and rain (Ullman *et al*. 1997)

Monitoring thrips in the flowers and on young fruit

Scirtothrips aurantii was the most abundant species found in the flowers and on young fruit in the open-pollinated seedling orchard at Nelspruit (Table 2). *Haplothrips gowdeyi* and *T. tenellus* were also found in high numbers during the flowering period. *Scirtothrips aurantii* was the only species found on the fruit as it developed beyond 9 mm. This was the only orchard where *S. aurantii* was found in such high numbers in the flowers. The orchard consisted of different selected seedlings and the population probably built up on the fruit and flowers of the early selections. By the time that most trees started to flower, *S. aurantii* was already present in high numbers. Therefore S. aurantii can be present in high numbers in the flowers, although numbers usually build upon small fruit.

In contrast to the Nelspruit orchard, *T. acaciae* was the most abundant species in the Zill and Sensation orchard at the ITSC Friedenheim Experimental Farm during 1996 (Tables 3, 4), while *S. aurantii* was absent. *Thrips tenellus* was also present in fairly high numbers in the Zill and Sensation orchard at Friedenheim.

Monitoring thrips with yellow card traps

Yellow sticky card traps were an effective method for monitoring thrips species and numbers. The traps were easy to use and handle. The thrips trapped were mainly *S. aurantii* and *T. tenellus*, while other species with very low abundance were omitted. *Thrips acaciae* was abundant at Friedenheim during 1996 and was thus included. The abundance of *T. tenellus* and *S. aurantii* in the Sensation orchard at Nelspruit during 1992/93 is illustrated in Fig. 1. The numbers of *T. tenellus* were high during the flowering period, but declined

Table 3. Thrips species collected at weekly intervals from mango flowers of the cultivar Zill at Friedenheim.

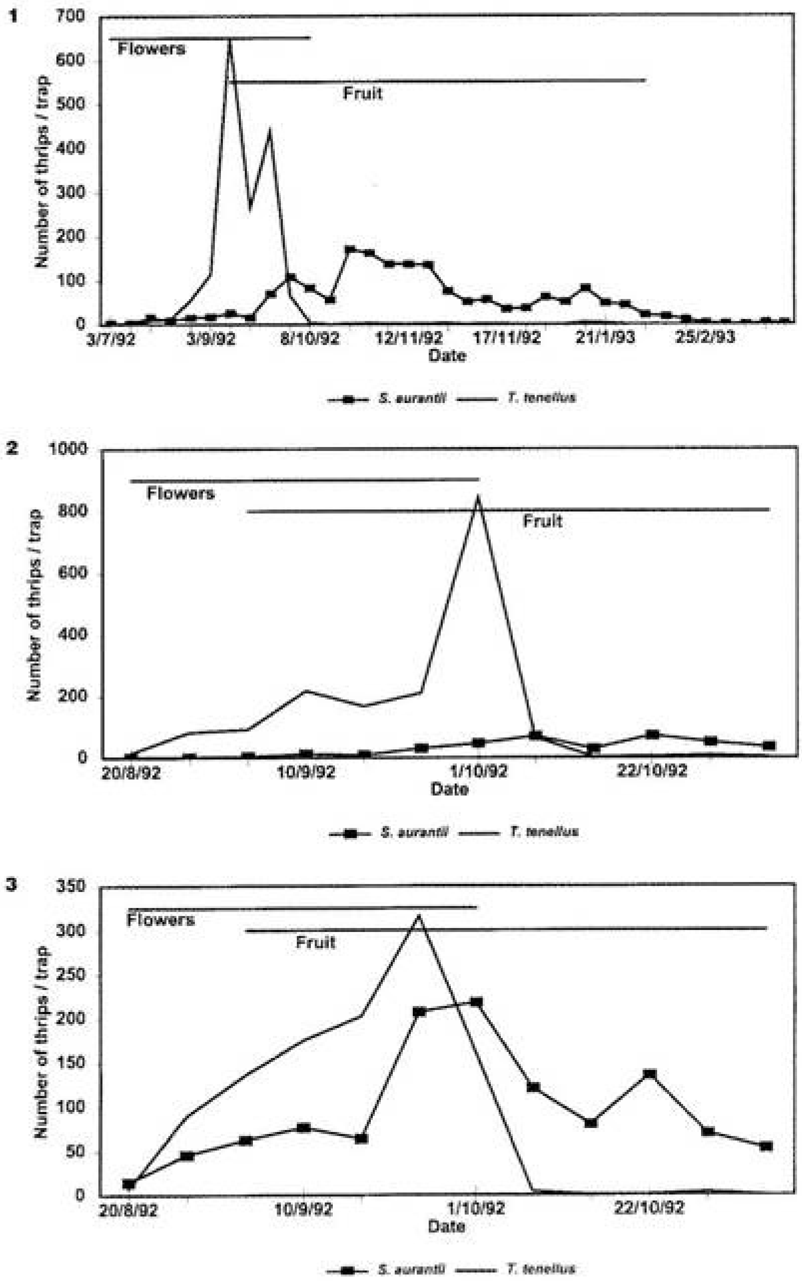
Date Status of flowers/fruit	Species (number collected)
1996-07-22 All flowers on panicle closed	-
1996-07-29 All flowers on panicle closed	-
1996-08-05 10 % of flowers on panicle open	-
1996-08-12 70 % of flowers on panicle open	-
1996-08-19 100% of flowers on panicle open	-
1996-08-26	*H. gowdeyi* (1), *T. acaciae* (1)
1996-09-02	*T. acaciae* (2)
1996-09-09	*H. clarisetis* (1), *H. gowdeyi* (1), *T. tenellus* (1)
1996-09-16	*H. clarisetis* (2), *H. gowdeyi* (1), *T. acaciae* (10), *T tenellu*s (11)
1996-09-23	*H. gowdeyi* (2), *T. acaciae* (13), *T. tenellus* (9)
1996-09-30	*H. gowdeyi* (1), *T. acaciae* (30), *T. tenellus* (13), larvae 8
1996-10-07 Average fruit length 9 mm	*H. gowdeyi* (1), *T. acaciae* (2)

sharply when fruit were setting so that virtually none were present during the fruiting period. The numbers of *S. aurantii* increased when fruit were setting and declined towards the end of the fruiting period. Similar results were obtained in the Zill and Fascell orchards at Friedenheim during 1992 (Figs 2, 3).

During 1996, in both the Zill and Sensation orchards at Friedenheim, high numbers of *T. tenellus* and *T. acaciae* were present during the flowering period, but declined when fruit were setting and developing (Figs 4, 5). Very low

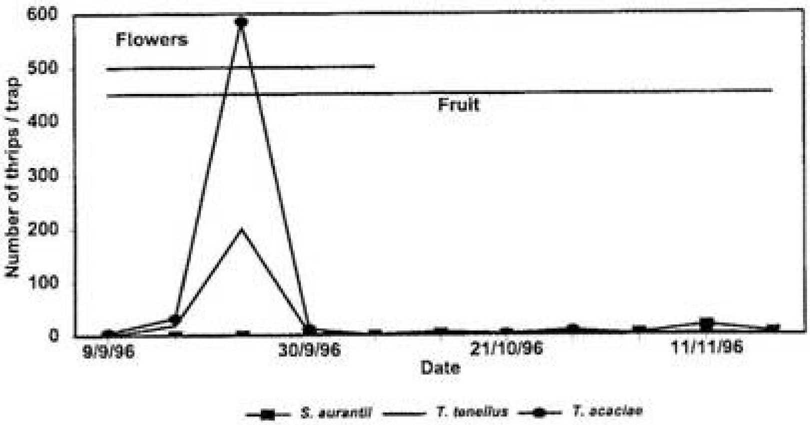
Table 4. Thrips species collected at weekly intervals from mango flowers of the cultivar Sensation at Friedenheim.

Date Status of flowers/fruit	Species (number collected)
1996-07-22 All flowers on panicle closed	-
1996-07-29 5 % of flowers on panicle open	*H. bedfordi* (1), *H. gowdeyi* (3)
1996-08-05 30 % of flowers on panicle open	-
1996-08-12 50 % of flowers on panicle open	-
1996-08-19 90 % of flowers on panicle open	-
1996-08-26 90 % of flowers on panicle open	Larvae (1)
1996-09-02 100 % of flowers on panicle open	*T. acaciae* (1)
1996-09-09	*T. acaciae* (4), *T. tenellus* (3)
1996-09-16	*H. clarisetis* (1), *H. gowdeyi* (2), *T. acaciae* (13), *T. tenellus* (2)
1996-09-23	*H. gowdeyi* (1), *T. acaciae* (95), *T. tenellus* (2)
1996-09-30	*T. acaciae* (28), *T. tenellus* (52)
1996-10-07 Average fruit length 19 mm	*H. gowdeyi* (1)



Figs 1-3. Numbers and species of thrips recorded from yellow card traps in mango orchards. Horizontal lines indicate the phenology of flowering and fruiting. **1**, Numbers of *Scirtothrips aurantii* and *Thrips tenellus* recorded from yellow card traps in a Sensation orchard at Nelspruit during 1992-1993; **2**, numbers of *S. aurantii* and *T. tenellus* recorded from yellow card traps in a Zill orchard at Friedenheim during 1992; **3**, numbers of *S. aurantii* and *T. tenellus* unrecorded from yellow card traps in a Fascell orchard at Friedenheim during 1992.

4



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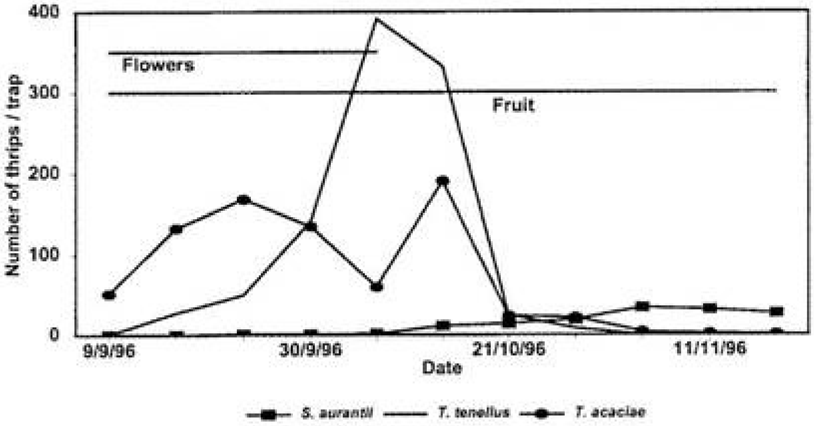


Figs 4-5. Numbers and species of thrips recorded from yellow card traps in mango orchards. Horizontal lines indicate the phenology of flowering and fruiting. **4**, Numbers of *Scirtothrips aurantii*, *Thrips acaciae* and *Thrips tenellus* recorded from yellow card traps in a Zill orchard at Friedenheim during 1996; **5**, numbers of *S. aurantii*, *T. acaciae* and *T. tenellus* recorded from yellow card traps in a Sensation orchard at Friedenheim during 1996.

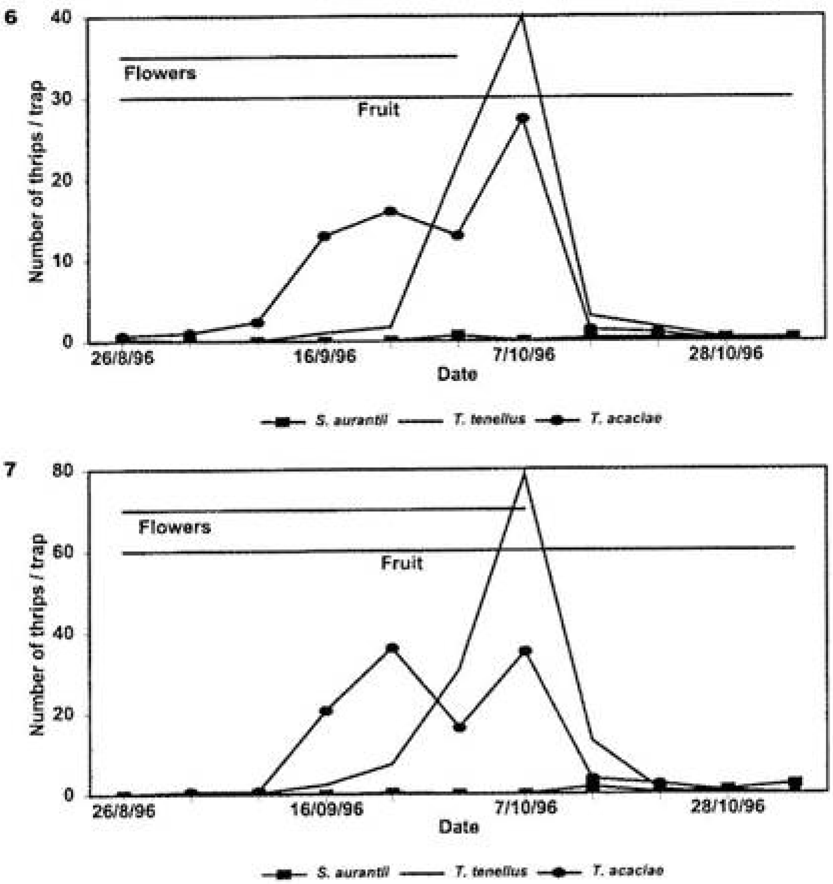
numbers of *S. aurantii* were present during both flowering and fruit set.

Scirtothrips aurantii, *T. acaciae* or *T. tenellus* were the most abundant species in the flowers. However, abundance of thrips species in the flowers varied seasonally and between orchards.

Monitoring thrips with DIE traps

The D/E traps yielded similar abundance patterns to yellow card traps, with high numbers of *T. tenellus* and *T. acacia*e present during the flowering period which declined when fruit were setting and developing (Figs 6, 7). However, in the Zill orchard, thrips numbers peaked about three weeks earlier on the card traps than on the D/E traps. Very low numbers of *S. aurantii* were present during the flowering period and when fruit were small.

Scirtothrips aurantii was the most widely distributed species in the survey when considering results from flowers, leaves and fruit. It was also one of only two species found to cause lesions on the fruit. Although *S. rubrocinctus* caused fruit damage, it was much less abundant than *S. aurantii* and did not seem to be of economic importance. When using both trapping techniques, *S. aurantii* was the second most abundant thrips during flowering and the most abundant after flowering. Based on these observations, *S. aurantii* is considered to be the most economically important thrips species on mangoes in South Africa.



Figs 6-7. Numbers and species of thrips recorded from dispersal/emergence(D/E) traps in mango orchards. Horizontal lines indicate the phenology of flowering and fruiting. **6**, Numbers of *Scirtothrips aurantii*, *T. acaciae* and *Thrips tenellus* recorded from D/E traps in a Zill orchard at Friedenheim during 1996; **7**, numbers of *S. aurantii*, *T. acaciae* and *T. tenellus* recorded from D/E traps in a Sensation orchard at Friedenheim during 1996.

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Notes on Traditional Uses of Khair (*Acacia catechu* Willd.) by Inhabitants of Shivalik Range in Western Himalaya

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Abstract

The article deals with the importance of ***Khair*** (also known as Catechu) in the life of rural and tribal communities inhabiting Shivalik range in western Himalaya, India. Catechu, a multipurpose tree species is widely used by the inhabitants for fodder, fuel, building material and in health care. Information on traditional uses and socio-economic importance of *A. catechu* were provided with reference to natives inhabiting foot-hills of Shivalik range in western Hiamlaya, India.

Key words: Traditional Use, Catechu, Shivalik range, western Himalaya

Introduction

Acacia catechu Willd. (Mimosaceae), locally known as Khair, is a medium sized deciduous tree with crooked and forked trunk. It is found growing in both natural and plantation forms in most of the parts of country up to an elevation of 1300m above mean sea level.

In Himachal Pradesh, catechu is widely distributed in Mandi, Hamirpur, Kangra, Solan, Sirmaur, Una, Chamba, Shimla and Bilaspur districts below 1300 m elevation (Chowdhery and Wadhwa, 1984 and Chauhan, 1999). Generally, *A. catechu* forms pure patches of ***Khair*** forests but it is also found in association with *Acacia modesta*, *Pinus roxburghii*, *Mallotus phillipensis*, *Dalbergia sissoo*, *Zizyphus* and other species (Champion and Seth, 1968).

In India, there are 3 varities of *A. catechu* namely, *Catechu, Catechuoides* and *Sundra. Catechu* is commercially used to obtain ***Katha*** (a concentrated filtered extract) in North India. It is found widely distributed in Jammu, Punjab, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, Bihar, Andra Pradesh and Orrissa. *Catechuoides* is found in terrai region of Sikkim, Assam and West Bengal, whereas *Sundra*, generally known as Lal Khair (red catechu) is found in Deccan, Gujrat, Rajasthan and southern Maharashtra (Brandis, 1984).

A. catechu is a multipurpose tree species. The heartwood of the tree is mainly used for extracting ***Katha*** and ***Cutch*** (decoction obtained after filtration) which are sold in the market. ***Katha*** is commonly used in ayurvedic preparations. Besides this, it serves as one of the major components in masticatory i.e. chewing of betel leaf (pan) in India.

A. catechu is a valuable bioresources and has been exploited commercially in tannin and Katha industry for decades (Annon., 1985). Besides its commercial importance, it is equally significant for the people particularly rural communities living in the vicinity of catechu forests as it is a subsidiary source of income to them. To a certain extent, these people are dependent on this plant to fulfill their day to day need of fuel, fodder, building material and others. This is the reason that catechu has become an integral part of socio-economic and cultural life of the people inhabiting the Shivalik range.

Though, information on traditional uses of catechu has been reported earlier by some workers like Kirtikar and Basu (1975), Jain (1991), Chatterjee and Pakrashi (1992) and Singh (2000), but, information on indigenous uses of catechu tree from Shivalik region has not yet been reported. That is why the present study was undertaken.

Study area

The present work is confined to Sirmaur and Solan districts of the state Himachal Pradesh in western Himalayan region. The area comes under Shivalik range, located at 31°11′ - 35°57′ north latitude and 76°52′ - 77°20′ east longitude between the elevation of 500m–1200m amsl.

Methodology

In order to document ***Khair*** associated traditional knowledge, various field surveys were conducted in ***Khair*** dominating forests in different localities like Nallagarh, Subathu, and Solan areas of Solan and Dhaulakauan, Poanta Sahib, Markanda and Nahan areas of Sirmaur districts. While interacting with rural and tribal people (Gujjars) during field studies, information was gathered through interviews following Jain (1989). Observations recorded on different traditional use are enumerated categorically and the lesser known uses are marked with an asterisk (*) mark.

Traditional Use

Medicine

- The decoction of bark mixed with milk is taken to cure cold and cough.
- The bark decoction is either alone or used in combination with opium to cure severe diarrhea.
- ***Katha*** after drying is applied on lemon slice and taken regularly with empty stomach to cure piles*.
- Heartwood of khair is boiled with other ingredients to prepare the decoction. It is taken as tea by the pregnant ladies to keep warm their body. It is also given to cure fever due to cold during the pregnancy*.
- A decoction is served to women after 2-3 days of child delivery, prepared by boiling katha along with Ellachi (cardamom). It is believed that it provides strength to the body* and also helps in secretion of milk.
- The water boiled with the heartwood chips of ***Khair,*** is used to take bath by women after delivery. It is considered beneficial to cure the body pains*.
- ***Katha*** or decoction of heartwood is applied in mouth and on tongue to cure mouth ulcer*. It is also applied externally on ulcers, boils, skin eruptions and on gums as disinfectant.

Fuel

- The dried logs, twigs and branches are largely used as fuel.

Fodder

- The trees are lopped heavily for their leaves used as fodder particularly for sheep and goats.

Building and Furniture Material

- The wood is considered durable and widely used by the inhabitants for house building material as poles and to prepare furniture like bed poles, tables etc.

House Hold Articles

- Wood of khair is preferred to prepare various parts of local plough, handles of axe, saw, sickle, hammer, spade and combs.

Socio-Religious Beliefs

- Khair is considered one of the sacred trees by the natives and wood is used in the religious ceremonies at the time of havans (yagna)*.
- Wood is considered sacred and used as one of the religious plants along with bhojpatra (*Betula utilis*) at the funeral ceremony. It is believed to provide *mukti* or *moksha* (peace to the heavenly soul)*.

Masticatory

- ***Katha*** (cutch) is widely used as a major ingredient in masticatory i.e. chewing of betel leaf (pan) by local people.

Fencing

- Cut branches are extensively used for fencing purpose by the farmers to protect agricultural fields and local grasslands from domestic livestock and wild animals.

Tanning

- The cutch is used locally for tanning leather and as dye to a great extent*.

Economic Importance

Besides traditional utility, *A. catechu* is widely utilized commercially for extracting **Katha** from the heart wood which costs around US $ 4-6 per kilogram in Indian markets. Cutch is used as adhesive in plywood industry and it is also used in preparing polishes and paints.

Conclusion

From the present study, it is envisaged that *A. catechu* has a great socio-economic importance as it is widely used for different purposes by the natives of Shivalik range. Besides, traditional and commercial importance, it has tremendous ecological significance. Because of its leguminous nature and soil binding abilities, it could be a suitable species for wasteland development.

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Bionomics and management of major thrips species on agricultural crops in Africa

R.T. Gahukar

Abstract: *Several thrips species are known to cause serious damage to agricultural crops in Africa. However, only five species of the family Thripidae are considered as economic pests, namely, Frankliniella schultzei (Trybom), Megalurothrips sjostedti (Trybom), Scirtothrips aurantii Faure, Sericothrips adolfifriderici Karny and Thrips tabaci (Lindeman). Nymphs and adult thrips suck the sap from leaf buds, leaves, flower buds, flowers and fruits, which become deformed or remain underdeveloped, often showing scars. Sonic species act as major vectors of viral plant diseases. Current pest-control practices include using resistant plant varieties, biological agents, cultural operations and chemical pesticides. However, more information is needed to formulate an effective, low-cost and eco-friendly pest-management strategy that can be adopted sustainably in the existing agricultural framework.*

Keywords: *thrips species; pest status and bionomics; control measures; IPM*

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Thrips form a small group comprising about 140 species of over 70 genera among the insects attacking agricultural crops in Africa (Faure, 1968; Bournier, 1971; Palmer, 1990). Most of the crop pests belong to the family Thripidae within the sub-order Tenebrantia. Taxonomic reviews are available on species found in central Africa (Priesner, 1952), west Africa (Bournier, 1971; Okwakpam and Youdeowei, 1980; Pitkin and Mound, 1973) and southern Africa (Faure, 1968) The family-group classification has been discussed by Mound, Fleming and Palmer (1980); and genera, species and subspecies relationships have been revised by Bournier (1971), Mound and Palmer (1981) and Palmer (1990).

The economic importance of each species has not been studied in different ecosystems where agricultural crops are cultivated, either under sustainable or commercial management, probably because thrips, being small in size, are difficult to see with the naked eye. Pest damage is often overlooked, as early symptoms of plant damage are not clearly visible and late symptoms can be confused with those of other sap-sucking insects such as aphids, jassids and whiteflies, which occupy the same niche. In such cases, thrips can be distinguished from other insects by the presence of short, segmented antennae and narrow wings with greatly reduced venation and marginal setae.

Thrips species are mainly plant feeders, although some of them are casual visitors, gall makers or predators. Plant injury during early pest attack is not easily detected, but late attacks become progressively obvious and in severe cases, plants wilt and die. For identification and overall estimation of population density, thrips from shoots, flowers or leaves are picked up with a fine brush, or plant parts are shaken or beaten over a small plastic tray or a sheet of white cloth. The collection can be safely preserved in a fresh mixture of 60% ethyl alcohol (10 parts) + glycerin (1 part) + acetic acid (1 part). This mixture keeps the specimens soft and distended, and facilitates slide preparation.

Limited studies of life history, damage potential, pest ecology and control measures have been undertaken, mainly in Nigeria, Senegal, South Africa and Kenya. This paper reviews these works and identifies the lacunae in research and development of the bionomics and management of five major species of Thripidae. The paper suggests future strategies for an eco-friendly, economical and effective control in the diverse farming systems presently adopted by farmers.

Cowpea or bean-flower thrips: *Megalurothrips sjostedti* (Trybom)

Synonyms of this species include *Physopus sjostedti* Trybom, *Taeniothrips meridiana* Moulton and *T. sjostedti* (Trybom). The species is present in Gambia, Nigeria, Cameroon, Congo, South Africa and East Africa, where it is a major pest of groundnut, bean and cowpea (Nyiira, 1971; Diambo, Yagoua, Renou and Martin, 1993). Occasional heavy damage on pigeon pea has been recorded in Nigeria by Okwakpam and Youdeowei (1980). Alternative cultivated hosts are coffee, mango, cashew nut and avocado (Hill, 1975). A wild host plant, *Centrosema pubescens* Benth, is common in Nigeria (Taylor, 1974). Up to 100% losses in cowpea yield have been reported from Ghana, Cameroon and Nigeria (Agyen-Sampong, 1978; Singh and Taylor, 1978; Ta'Ama, 1983). However, a significant reduction in the yield of dry grains occurs only when infestation extends beyond 35 days from planting (Ezueh, 1981).

Leaf buds and bracts/stipules of cowpea are damaged during the pre-flowering period, resulting in deformation with a brownish-yellow mottled appearance. Flower-buds become brown and eventually abort, leaving behind dark red scars (Akingbohungbe, 1982). Early attack may start when the flower peduncle elongates, which may cause flower drop (Taylor, 1969). If the flowers are damaged, flower parts become distorted, malformed and discoloured (Singh and Taylor, 1978). Feeding punctures can also be seen at the base of the petals and stigma. Attack on anthers and stamens results in early wilting of pollen and, subsequently, reduction in both pollination and fruit setting occurs (Taylor, 1974).

Breeding is parthenogenetic. Females lay small eggs in flowers and flower-buds, which hatch in a week. The orange-coloured second and third instar nymphs are mainly found in flowers. Pupation is in soil, and the adults live for about two weeks. Adults are 1.5 mm long and brownish, with a paler antennal segment III and forewing base. The fore vein of the forewing has a small gap in the distal setal row. Abdominal tergite VIII has a number of microtrichia grouped from the antero-lateral area to the spiracles. The life-cycle is completed in 10-15 days and several generations are completed in a year.

In order to sample thrips in cowpea, Salifu and Singh (1987) evaluated five methods (ie sticky traps, water traps, sweep netting, plant shaking and collection of insects from whole plants). From the point of view of low sample variance, low cost and accuracy in absolute population trends, plant shaking and water traps were found to be suitable and practical methods for rapid estimation, although other insects were also caught in the water traps, which made identification rather difficult. Similarly, Salifu and Hodgson (1987) used two methods (Iwao's regression procedure and Taylor's power law analysis) to determine the relationship between the mean and variance of insect counts. Both methods showed that thrips were randomly distributed within the canopy of the cowpea crop, initially at low populations. At later high densities, Iwao's method provided a better fit of population dispersion of nymphs and adults. Sequential sampling plans were then developed using critical stop lines derived from both methods.

Population densities are high in dense plantings (Kyamanywa and Tukahirwa, 1988) and during dry seasons, which favour the pest's multiplication not only on cowpea (Agyen-Sampong, 1978; Ezueh, 1981), but also on weeds present in the field or surrounding areas (Ezueh and Amusa, 1988). Insects migrate to the main crop at the pre-flowering stage.

Several methods of pest control have been tried. Weeding is helpful to destroy hiding sites of insects present in the field and on border plants (Ingram, 1969; Ezueh and Amusa, 1988). Application of phosphatic fertilizers makes the plants strong enough to tolerate pest attack (Nangju, Flinn and Singh, 1979). However, the most effective cultivation method is the intercropping of cowpea or beans with cereal crops such as pearl millet (Gahukar, 1989), sorghum or maize (Kyamanywa and Tukahirwa, 1988; Dissemond and Hindorf, 1990). In Nigeria, plantings of cowpea sown 12 weeks after maize suffered the lowest pest infestation (Ezueh and Taylor, 1984), and up to a 42% reduction in thrips numbers was noticed on cowpea peduncles due to the activity of the major predators, *Orius amnesius* Ghauri and *O. albidipennis* (Reuter) - Anthocoridae: Heteroptera (Matteson, 1982). To facilitate the screening of cowpea genotypes, Jackai and Singh (1988) developed a scale of 1-9 for evaluating the pest damage, in which 1 = no browning/ drying of stipules, leaf-buds or flower-buds, 3 = initiation of drying, 5 = distinct browning/drying of stipules, leaf- buds or flower-buds, and starting of bud abscission, 7 = severe flower-bud abscission and failure of peduncles to elongate, 9 = very severe bud abscission and the presence of short, barren peduncles. By this method, resistant cultivars were selected, namely, Tvx 3236, IT 845-2246, Tvu 1509, Tvu 7274, Vita 4, Vita 5 (Taylor, 1974; Salifu, Singh and Hodgson, 1988; Afun, Jackai and Hodgson, 1991), ER-1 (Nangju, Flinn and Singh, 1979) in Nigeria, and cvs 58-57, IT 81D-1032 and local mougne in Senegal (Gahukar, 1987). Plant resistance appeared to be associated with antibiosis, which is manifested by extended development of immature stages and reduced adult survival (Salifu, Singh and Hodgson, 1988). Since ethylene is produced by injured peduncles, Wien and Roensingh (1980) experimented with a synthetic plant-growth regulator, ethephon ([2-chloro-ethyl] phosphoric acid), which, when sprayed on to plants, translocates to actively growing tissues and breaks down to form ethylene. This technique should prove helpful in identifying resistant sources.

Among the synthetic insecticides used, deltamethrin at 20 g a.i./ha (Price, Chambuya and Machange, 1983), monocrotophos at 500 g a.i. (Ayoade, 1975; Mensah, 1988), DDT at 1 kg a.i. (Nyiira, 1971), bifenthrin at 7.5 g a.i./ha (Diambo, Yagoua, Renou and Martin, 1993)) on cowpea, endosulfan at 600 g a.i./ha on groundnut (Tarimo and Karel, 1987) and DDT at 1 kg a.i./ha on bean (Ingram, 1969), and 2-4% extract of neem-seed powder or 2% leaf extract on cowpea (Tanzubil, 1991), were quite effective in reducing pest numbers and increasing crop yield. While comparing sprayers (compressed and motorized) and spraying methods (two alternate rows *versus* whole plot), Ayoade (1975) found no difference between these treatments. Generally, 2-4 sprays during flowering are given (Nangju, Flinn and Singh, 1979), but up to six applications, at an interval of 7-10 days, of a suitable insecticide were required to save a cowpea crop from thrips attack in Tanzania (Price, Chambuya and Machange, 1983). However, monitored spraying has been recommended by Afun, Jackai and Hodgson (1991), as this technique saves labour and insecticide costs. A practical and cost-effective pest-control strategy consisting of widely-spaced planting, cowpea intercropped with cereals, use of tolerant cultivars and spraying of plant products, such as neem-based formulations, is required for subsistence-farming systems.

Cotton bud thrips: *Frankliniella schultzei* (Trybom)

Synonyms include *Physopus schultzei* Trybom, *Frankliniella sulphurea* Schmutz, *F. delicatula* Bagnall, *F. dampfi* Priesner, *F. dampfi* ssp. *interocellaris* Karny and *F. africana* Bagnall. This thrips species has a wide distribution in the African tropics and subtropics. Cotton, groundnut, beans and pigeon pea are the major hosts. However, due to its polyphagous feeding habit, tomato, sweet potato, coffee, sorghum, chillies, onion and sunflower are also attacked (Hill, 1975). Recently, damage to apple fruits has been reported from South Africa (Jacobs, 1995). But no data on yield losses have been gathered in any of these crops. Silvery scars are seen on the upper surface of leaves due to sap sucking. Young leaves become distorted and if the attack is on seedlings, their growth is retarded by several weeks. Adults prefer young leaves and flowers, whereas nymphs prefer leaf-buds, but all of them usually concentrate on flowers. Mature plants are little affected.

A mated female lays tiny, whitish eggs in leaf tissues and buds. Unmated females give rise to males only. Eggs hatch in 5-8 days. Young nymphs are yellow or white and wingless, and undergo three instars in 8-10 days. Pupation, which occurs in soil, lasts 4-7 days. The pale to dark brown females are 1.5 mm long with paler bands across the abdominal segments. Males are smaller than females and have brown to yellow bodies. The comb of microtrichia on the posterior margin of abdominal tergite VIII is represented by only a few small teeth laterally. The head has two pairs of ocular setae and 7-8 segmented antennae. The forewings have two complete rows of first-vein setae. Three pairs of long setae are present on the vortex of the second and third thoracic segments. Adults may live for three weeks, but under normal conditions, the life-cycle is completed within 3-5 weeks. Several generations are possible in a year, as thrips survive during the off-season on weeds and plants left after crop harvesting.

Pest populations are generally abundant on plants suffering from a lack of water (Wheatley, Wightman, Williams and Wheatley, 1989). In Senegal, this situation usually arises at peak flowering time in September. when the maximum population of 127 thrips/10 buds in cowpea has been observed (Gahukar, 1987). The pollen diet increases the longevity and fecundity of thrips, and a temperature of <30°C and wind velocity of 10 km/h or less are congenial for dispersal. Other possible factors responsible for pest outbreaks and abundance need to be investigated in different agroclimatic zones.

Weeding is routinely being used as a practical measure of pest control (Hill, 1975). Intercropping of cowpea with pearl millet under different configurations significantly reduced the thrips' numbers (Gahukar, 1989). In Senegal, cowpea cvs. 58-57, IT 81D-1032 and a wild groundnut, *Arachis chacoense*, showed tolerance to pest attack (Gahukar, 1987). Studies on the mechanisms of plant resistance and associated factors need urgent attention from breeders. In South Africa, Jacobs (1995) recommended the monitoring of thrips with blue sticky traps at the 'green tip' stage of apple, the first spraying of methamidophos between full bloom and 75% petal fall, with a second spraying 1-2 weeks later. At present, field sanitation, intercropping, use of sticky traps and early-crop-stage protection by suitable insecticides seem to be of practical value.

Onion or tobacco thrips: *Thrips tabaci* Lindeman

This is a cosmopolitan, polyphagous insect attacking vegetables, spice and fruit crops, pulses, cotton, etc in all parts of Africa. The pest has caused significant economic losses in onion crops in Zimbabwe (Wells, 1980), Ghana (Halteren, 1970), Kenya (Kimani and Mbatia, 1993) and Sudan (Kisha, 1979); tobacco in Botswana (Shaw, 1979); potato in Egypt (Youssef, El-Okda and El-Assar, 1986), and tomato (Daiber, 1996a), garlic (Daiber, l996b), grapes (Schwartz, 1988) and asparagus (Daiber, 1994) in South Africa. Due to laceration of leaf tissues and sucking of sap, the leaves curl up and wrinkle, and often show silvery flecks. In severe infestation, plants appear blighted and may wilt and die within 2-3 days. Leaf shedding occurs in cotton, and the fruits of grapes drop prematurely. Kisha (1979), after studying the population dynamics on onions in Sudan, fixed the economic threshold at 5-10 nymphs/plant. However, yield losses should be assessed systematically in all the major host crops in each region.

Almost 50 white eggs are laid in batches by a female in notches in the epidermis of the leaf and stem of young plants. The white or yellow nymphs undergo two moults. The development periods of egg, nymph, pre-pupa and pupa are 4-9, 4-6, 1-2 and 4-6 days respectively. Pupation occurs in soil at a depth of 2.5-5 cm. Adults are 1 mm long, yellow or brown, with darker transverse bands across the thorax and abdomen. The forewing has a fore-vein with 3-6 distal setae. Abdominal pleurotergites are covered with rows of ciliate microtrichia. The life-cycle is generally completed in 23-33 days. In Egypt, thrips populations appear in cotton during the second week of April, with maximum density in May-June, and disappearing in July. Therefore, the maximum numbers of predators are present in late June and during July (Abou El-Hagag, 1998b), whereas in onion crops, two peaks in pest populations were observed at the end of December and mid-March (El-Gendi, 1998). Among the five generations that the pest completes in a year in Egypt, the third is the most dangerous (Hamdy and Salem, 1994).

Higher temperatures and low relative humidity (RH) can reduce the population by 35-46% (Sharaf, Ismail, Ali and Hashem, 1993), the most favourable conditions being 21.1-23.6°C and 52% RH (Hamdy and Salem, 1994). In Egypt, infestation levels were high in cotton fields that were ploughed shallowly, sown very early (Sewify, El-Arnaouty and Belal, 1996) and received frequent irrigation, or when sowing was done after maize (El-Mahal and Nasr, 1966). Transplanted cotton suffered less infestation than normally sown cotton in Egypt (Radwan, Abdel-Hamid, El-Sadaany and Romeilah, 2000). Late-sown onions (Dawood and Haydar, 1996) and highly fertilized tomato (Omar, Haydar and Afifi, 1993) suffered higher pest infestation. Intercropping of onion with cotton planted in ridges (Sharaf, Ismail, Ali and Hashem, 1993), or onion and garlic with tomato (Afifi and Haydar, 1990) has been recommended. Local onion cvs. Giza-6 and Behiri, currently cultivated by farmers in Egypt, were found to be tolerant to thrips attack (El-Gendi, 1998). However, further breeding to develop resistant cultivars was not carried out.

Predaceous insects such as staphilinid, *Paederus alfierii*, Chrysopid, *Chrysoperla carnea* Stephens, Coccinellids, *Coccinella undecimpunctata* L., *Scymnus* spp., anthocorid, *Orius albidipennis* (El-Gendi, 1998) and phytoseiid mite, *Amblyseius* spp. are known to occur in fields when the thrips population is high. Chyzik, Klein and Ben (1995) studied the biology of *O. albidipennis* in the laboratory and found that thrips were better prey than *Ephestia cautella* (Wlk.) eggs or *Tetranychus urticae* Koch adults, on which up to 98% of the predators survived.

Insecticides have been used extensively on agricultural crops: eg carbofuran granules at 0.025 g a.i./onion plant or 0.24-0.53 kg a.i./ha, 1.08 kg a.i. malathion or phenthoate/ha in Sudan (Kisha, 1979, 1983), and dieldrin at 70 g a.i./ha in Kenya (Bullock, 1963). Other synthetic insecticides such as quinalphos, dimethoate, fenvalerate, prothiophos, actellic mixed with lannate, triazophos and cypermethrin gave >90% kill a day after treatment on onion (Mourad, 1992; Dawood and Haydar, 1996). Foliar sprays of phoxim, carbaryl, pirimiphos-methyl, dicrotophos, chlorfenvinphos, methomyl, mephosfolan, monocrotophos, dichlorvos and methamidophos were also quite effective in reducing pest numbers and plant-infestation levels (Halteren, 1970; Swailem and Abul-Ela, 1975; Kisha, 1983). Two to five applications at fortnightly intervals were necessary to control the thrips populations in Ghana (Halteren, 1970), whereas cypermethrin sprayed at 500 g a.i./ha on onion controlled the pest in Ethiopia (Shimeles, 1998). Under South-African conditions, Jacobs (1995) recommended the monitoring of thrips with blue sticky traps at the 'green tip' stage of apple, spraying of methamidophos between full bloom and 75% petal fall, and again 1-2 weeks later.

In Egypt, when monocrotophos at 200 ml a.i./ha mixed with a mineral oil ('misrona') or cotton-seed oil was sprayed on cotton, there was an additive residual effect. On the other hand, these mixtures proved to be toxic when monocrotophos was sprayed at 400 ml a.i./ha. Popular insecticides (eg acetamiprid, milbemictin or thiocyclam hydrogen oxalate) proved to be inferior to monocrotophos in reducing pest populations (Hamid and Korkor, 1999). In another trial, monocrotophos gave a 70% kill 14 days after application, although pirimiphos ethyl, furathiocarb, omethoate or carbosulfan gave a better initial kill (Kandil, Barakat, Saleh and Ibrahim, 1991). For increasing the bioactivity of a mixture of dicofol + omethoate, an activator at 50% and an enhancer or star oil at 25% was added (Moustafa, Abou-Seeda and El-Attal, 1990). Among several insecticides tested for their knock-down and residual effects, methamidophos, omethoate and monocrotophos were found to be promising, while cyanophos and thiometon were the least effective (El-Dahan, Kady, Khalil and Serig, 1990).

Pest management in cotton was studied in Egypt using modern pesticides, where three sprays of methomyl at 3-weekly intervals decreased the number of important predators (Abou-El-Hagag, 1998a). Thus, safer pesticides need to be identified and studied. For example, El-Hamady and Sholoa (1999) recommended treatment of cotton seeds with imidacloprid at 7 g/kg seeds. The residual effect of imidacloprid lasted up to seven weeks after application and later declined to 0.016 ppm. From this application, the activity of catalase and invertase in the soil was significantly reduced after 3-4 weeks, but the activity of dehydrogenase, phosphatase and urease were least affected. As this technique assures the safety of predators, a package comprising an early sowing of imidacloprid-treated seeds, fertilizer management and intercropping should be recommended to farmers.

Pulse thrips: *Sericothrips adolfifriderici* Karny

Synonyms of the species include *S. occipitalis* Hood and H*ydatothrips adolfifriderici* Karny. This is a common thrips species attacking pulses in Africa. It causes serious damage to off-season (irrigated) cowpea (Taylor, 1974; Ezueh, 1981). Thrips injury is initially responsible for scarring, yellowing and silvering of leaves. Later, leaves become deformed and brownish on the underside, and necrosis occurs. As the plant grows, the pest attacks shoots and flowers, resulting in stunted plant growth and flower drop. In Nigeria, plant damage up to 42 days after planting did not affect cowpea yield, but when 50% of the plants were damaged, a significant loss in cowpea yield was observed (COPR, 1981). An estimation of damage is done 25-30 days after planting on a scale of 1-5, in which 1 = 0-1% of plants attacked, 2 = 2-5%, 3 = 6-25%, 4 = 26-50%, and 5 = 51-100% of plants attacked (Taylor, 1964). Neither economic thresholds nor economic-injury levels have been worked out in pulses.

Eggs are laid on aerial plant parts. After hatching, orange or yellow nymphs gather on the underside of leaves. Pupation occurs on the ground beneath the host plants. Adults are 1 mm long with pale yellow antennae possessing brown apical segments. The head is brown at the anterior side up to the occipital ridge and pale yellow at the posterior side. The wings are brown with a pale band on the base at the rear; the legs are pale. Tergites IV and X of the abdomen are pale yellow, whilst tergites VII-IX are dark brown. A generation takes about two weeks, and several generations may be completed depending upon the weather and the availability of host plants. Dry weather is favourable for pest development and heavy rains wash thrips off the plants (Taylor, 1964; Ezueh, 1.981).

Insecticides have usually been used to control this pest in cowpea. Four to five sprays at 7 to 10-day intervals of deltamethrin at 25 g a.i./ha, monocrotophos at 200-400 g a.i., dicrotophos at 350-400 g a.i, dimethoate at 1.12 kg a.i., phosphamidon at 150-200 g a.i., or DDT at 1 kg a.i./ha produced significant pest mortality (Nyiira, 1971; COPR, 1981). Similarly, granules of disulfoton, furadan and thimet at 1-1.5 kg a.i./ha, applied at planting or 20 days after planting, were equally effective in West Africa (Taylor, 1964; COPR, 1981). During the screening tests of cowpea genotypes in Nigeria, cvs. Tvu-1509 and Tvu-7274 had suffered fewer thrips attacks and thus demonstrated the possibility of their utilization in breeding programmes. Such cultivars with potentially higher yields than local ones should be sprayed whenever required, after considering the economic thresholds. Synthetic insecticides may possibly be avoided for the safety of consumers, as pulses are consumed as green vegetables.

Citrus thrips: *Scirtothrips aurantii* Faure

This species distributed in Egypt, Malawi, Sudan and South Africa (Hill, 1975) is specific to citrus. It rarely attacks mangoes in South Africa (Brink, 1995) or banana in central Africa (Palmer, 1990). Feeding by nymphs and adult thrips on fruit results in a ring of brownish scales around the base of the fruit. Scribbling, russetting and irregular scars appear on leaves and upper parts of the fruit. Young leaves may be malformed, resulting in stunted growth (Kamburov, 1991; Brink, 1994).

Bean-shaped eggs (>0.2 mm) are inserted by a female into the soft tissues of leaves, stems or fruit. Egg, nymphal and pupal stages last 1-2 days, 1-2 weeks and 1-1.5 weeks respectively. The yellow/orange, cigar-shaped nymphs seek sheltered places and pass through two resting stages known as pre-pupa and pupa respectively. Adults are reddish-orange (<1 mm long) with feather-like wings. Males are rare and females normally reproduce parthogenetically. Adults may live for several weeks. Greater pest populations have been noticed during flushing of mango trees, on small fruits and when fruits were in contact with each other (Brink, 1994).

Two phytoseiid mites, *Euseius addoensis addoensis* (Grout and Stephen, 1994) and *E. citri* (Grout, 1994) are major indigenous predators of citrus thrips in South Africa. They significantly reduced pest numbers at petal fall when thrips populations exceeded 1 mite/leaf (Grout and Richards, 1992a), but significant reduction in both pest numbers and plant damage was possible by spraying with insecticide towards the end of the main flowering period (ie when 75% of the petals have fallen). The common insecticide, lime sulphur, was sprayed twice at 10-day intervals (Hill, 1975). Among modern insecticides, sabadilla alkaloids (0.0024% a.i.) mixed with sugar (0.96%) or methiocarb (0.016% a.i.) mixed with sugar (0.4% a.i.) (Grout and Richards, 1992a) were found to be more toxic to *E. addonensis* than tartar emetic (0.398 % a.i.) mixed with sugar (0.4% a.i.). However, for unknown reasons, *S. aurantii* has developed resistance during recent years to tartar emetic baits and, therefore, insecticide-resistance management is necessary, probably by including plant products and rotation of pesticides in the control schedule (Grout, Stephen and Croix, 1996). This would also help to conserve the predaceous mites in citrus orchards.

Role of thrips in disease transmission and spread

Thrips are important vectors of virus diseases of some food crops cultivated in Africa. The major diseases are described below.

Tomato spotted wilt (synonyms: peanut spotted wilt, chlorosis, bud necrosis)

This tospovirus causes wilt disease in groundnut, potato, eggplant, pepper, tomato and legumes. The virus is transmitted by thrips species, *F. schultzei*, *T. tabaci* and *Scirtothrips dorsalis* Hood (Daiber, 1996a). Only adults can transmit this virus, although it is acquired by nymphs after feeding on infected plants. The virus is very unstable, both physically and chemically. This seed-borne virus can also be transmitted by sap inoculation. Amin, Reddy and Ghanekar (1981) described the application of a haemagglutination technique to detect viral antigens in thrips that had been exposed to infected leaves. Both virus and vectors have a wide range of hosts (>100 plant species) throughout Africa. Heavy losses in groundnut have been reported due to this disease (Wightman and Amin, 1988; Palmer, 1990).

The disease is manifested by distinct round spots and lines on leaves, which are small and round, and often curled inwards. There is blight and blackening of apical shoots and stems, and leaflets show general chlorosis. Defoliation may occur, but plants remain stunted due to short internodes and auxiliary shoots. In late infection, a few branches will show a ring of spots or bud necrosis. Subsequently, the whole plant turns yellow, wilts and dies. Diseased plants produce only a few small and deformed flowers and seeds. Moreover, the seed testa and cotyledons are wrinkled, with heavy darkened lesions. On tomato fruits, brown lesions and blotches or rings appear as primary symptoms. Infected fruits are small and soft. Secondary symptoms include a stunted and bushy look to the whole plant.

To check the spread of this disease, removal and destruction of weeds, alternative host plants and debris of plants of the Solanaceae family is necessary. Seeds from infected plants should be avoided, as should delayed sowing. On the other hand, dense planting can be a practical means of reducing the impact of the disease. Transplanting of seedlings during humid and warm weather favours the vector's multiplication. A few rows of sunn hemp (*Crotalaria juncea* L.) trees around the tomato crop act as a barrier to pest migration, which is otherwise facilitated if new crops are planted near the old ones (COPR, 1981). lntercropping and mixed cropping of groundnut with non-leguminous crops effectively control the vectors (COPR, 1981). Natural enemies of thrips (ladybird beetles, syrphid flies, spiders) are found in very low numbers and resistant varieties are not yet available. Therefore, insecticides are often sprayed on plants showing early disease symptoms. But again, such applications may be undesirable and catastrophic. For example, spraying with dimethoate at 100 g a.i./ha has been shown to increase the disease incidence in groundnut. Wightman and Amin (1988) attributed this phenomenon to the following facts:

(1) death of natural enemies of thrips;
(2) the shallow piercing probes of thrips probably protect them from the systemic action of insecticides;
(3) thrips hide within folded leaflets and therefore are well protected from their natural enemies; and

(4) insecticides may induce hyperactivity among populations, resulting in a wider distribution of viruliferous individuals.

Thus, preventive measures against thrips and disease should be planned and implemented well in advance.

Cowpea mosaic virus (synonym: yellow mosaic virus)

This is a sap-transmissible comovirus causing occasional damage to bean crops in Kenya, Tanzania and Nigeria. If disease infection is during early plant growth, it can destroy the whole crop, reducing yields to nil (Singh and Allen, 1979). At low levels of infection (1-5% of plants), the virus is seed-borne, and the infection rapidly spreads to the entire crop through its vectors, *M. sjostedti* and *S. adolfifriderici*.

Young cowpea leaves develop a bright yellow or light green mosaic with moderate distortion and reduction in size. Severely infected leaves turn yellow. Generally, different virus isolates show different symptoms ranging from an inconspicuous green mottling to severe mosaic, blistering and death of the plant (Singh and Allen, 1979). Enzyme-linked immunosorbent assay (ELISA) and other laboratory tests are used to confirm the virus infectivity (Allen and Van Damme, 1981). The easiest method to reduce disease incidence in cowpea is to destroy weeds, alternative hosts of thrips and diseased plants as soon as early symptoms appear in the field. In Nigeria, cultivars Victor, K 798, Vita 3, brakha, K 892, GRO-IT, Clay K-713 and Arlington were reported to be resistant to the virus (Williams, 1977). These research findings are being exploited in order to breed resistant cultivars that will be recommended for general cultivation.

Brown spot disease

This disease, transmitted by *S. aurantii*, has been recorded in banana plantations in central Africa (Palmer, 1990). Young leaves are usually attacked, which first show green spots, and later, brown ones. A scaly brownish ring develops on fruits.

As the *Acacia* tree is an important alternative host, planting of banana near these trees should be avoided. Destruction of infected plants helps to reduce disease pressure. Hill (1975) recommended insecticide spraying of leaves and fruits at the end of the main flowering period to keep thrips populations at low levels. No curative measures are available for farmers' use in case this disease is spread to other countries and becomes severe on any other crop.

Tobacco streak virus (synonyms: yellow ring spot, leaf malformation)

This sap-transmitted disease, found on nearly 30 plants, is of minor importance as it is presently limited to certain zones. It is spread by *T. tabaci* adults, which carry virus-infected pollens. Infection also occurs through wounds in plant tissues caused by insect feeding and oviposition (Sdoodee and Teak 1987). A ring of yellow spots occurs on the leaves, which subsequently become malformed. Tomato fruits show necrotic sunken lesions. Due to the lower economic importance of the disease, no control measures have been worked out.

Future thrusts

It is imperative to identify lacunae in the research and extension activities so as to facilitate planning of an integrated pest management (IPM) strategy that can be adopted even by small farmers. The average African farmer is mainly dependent on food crops for his or her livelihood, and grows these crops according to the family's needs. Sustainable agriculture with existing cropping systems needs to be studied from the point of view of environmental protection, socioeconomics and the practicability of control measures.

The thrips complex present in Africa has not been fully documented. It is therefore necessary to survey and identify thrips species in the production zones of major agricultural crops. Peaks in population abundance and the seasonal distribution of major species in each agro-ecosystem would facilitate the monitoring procedures and also, in certain cases, modelling. A few of the species are widely distributed and their role as virus vectors and disease-disseminating agents has been recognized. Thrips may also transport the spores of mildews, moulds and rusts from diseased plants to healthy plants. Observations on the migration of vectors and their establishment in a crop may therefore be periodically undertaken. Precautions for preventing the spread of important plant diseases, particularly of food crops, need to be formulated urgently.

Information on pest bionomics and factors affecting the abundance and distribution of their populations should prove helpful in planning control strategies and deciding on the economic thresholds that are yet to be determined for the majority of thrips species.

Predators are their major natural enemies, but they are presently unable to suppress the abundance of thrips. Therefore, new indigenous predators are being researched and their potential studied, eg *Euseius orygmus*, *E. tutsi*, *Typhlodromalus* spp., *Amblydromalus* spp. (Grout, 1994) and *Haplothrips bedfordi* (Brink, 1994). Similarly, an exotic predator of *S. aurantii*, *Neoseiulus cucumeris*, was proposed, but it could not take the place of the indigenous predator, *E. a. addoensis*, on citrus, and is unlikely to survive and control the pest in South Africa (Grout and Stephen, 1994). Favourable conditions for the conservation and augmentation of potential indigenous predators maybe provided. For example, the predatory mite can survive on the pollen of trees that are used as windbreaks in South Africa, especially *Carpoprotus muirii* and *Casuarina cunnighamiana* (Grout and Richards, 1992h) and *Eucalyptus torelliana* (Grout and Stephen, 1995a). Planting these trees around citrus plantations can therefore help to maintain populations of predatory mites during the autumn when prey is in low numbers. Other predatory mites, eg *Erythracarus* sp. (Anystidae), *Hemicheyletia bakeri* (Cheyletidae), *Neocumaxoides rykei* (Cunaxidae), *Laelaspis* sp. nr *vitzthumi* (Laelapidae), *Neoseiulus barkeri* and *Proprioseiopsis pascuus* (Phytoseiidae), found in leaf litter and soil in Zimbabwe need to be studied for their efficiency and use in controlling citrus thrips (Grout and Veckermann, 1999). A eulophid, *Goetheana incerta*, parasitizing *S. aurantii* in Swaziland requires only 21-25 days to complete its life-cycle (Grout and Stephen, 1995). With the advantage of a short life-cycle, this parasitoid may be multiplied in the laboratory and released over a large area, although establishment and recovery studies need to be undertaken first. Food sprays may also be tried as one of the solutions to help the conservation of well adapted species. If these efforts are successful, natural enemies can then be dispatched to neighbouring countries on the continent.

The breeding of local landraces and resistant sources with high-yielding popular hybrids and synthetics should be continued and tested in farmers' fields for adaptability. Seed treatment with imidacloprid has proved to be effective and safe to predators. This practice therefore merits attention, and may be complemented by 1-2 sprays of plant-based insecticides. Neem products are easily available in Africa, and the preparation of simple products such as leaf extract, seed-kernel extract and neem oil can be taught to farmers so as to save plant-protection costs. These plant products and neem-based commercial formulations fit well with IPM as they are effective and eco-friendly. Their use is advocated even as a preventive measure. However, if the pest populations cross economic thresholds or economic injury levels, 1-2 sprays of a recommended insecticide may be given, while monitoring carefully for residues.

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