Food and Agriculture Organization of the United Nations

FAO Regional Vegetable Disease Diagnosis, Ecology and Management Training

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Section 1 Background

Integrated Pest Management (IPM) is a multifaceted, ecologically-based strategy that relies on close observation and monitoring of a crop before making management decisions. IPM combines a number of techniques to effectively suppress plant diseases and insect pests in an economically and environmentally conscious manner. Utilizing IPM to manage plant diseases relies on an understanding of disease ecology, symptom diagnosis and management techniques.

Considerable efforts have been made to improve farmer understanding of pest insect management techniques within IPM systems. However, there is still considerable scope for progress to be made with regards to capacity building for effectively dealing with major vegetable disease problems, particularly for off-season vegetable production in the tropical lowlands. Newly emerging challenges in disease management include insect vector transmitted viruses.

Developing a greater understanding of vegetable diseases diagnosis, ecology and management will strengthen the IPM farmer education work implemented by the FAO supported National IPM Programmes in the Asian region. To this end, FAO and the Cambodian National IPM Programme conducted a Regional Training on Vegetable Disease Diagnosis, Ecology and Management (RVDDEM) which was held in Phnom Penh, Cambodia from 20-28 September 2007.

This training provided IPM facilitators with information and practical training on the principles of disease management (bacteria, fungi, virus, and nematodes) in the Solanum, Leguminaceae, Brassicaceae, Allium and Cucurbitaceae crop families. This training also provided an opportunity to review disease management principles, discuss and share local experiences, undertake practical activities to further develop understanding of disease physiology, improve disease symptom diagnosis and management and develop training materials and learning exercises that can be incorporated into the curricula for Farmer Field Schools (FFS) and FFS follow up training activities. Specific training objectives included:

- Review concepts and principles of disease management within IPM farming systems, with a focus on off-season vegetable production for the tropical lowlands;
- Exchange knowledge and experiences on disease management strategies within IPM programmes in the home countries of participants;
- Participate in field visits and practical activities to develop greater understanding of how diseases damage plants and how these can cause yield loss;
- Improve disease symptom diagnosis and management skills;
- Learn more about the latest developments in vegetable disease management, including innovations developed by both the public and private sector;
- Formulate utilization plans for how new knowledge gained and skills developed can be utilized, including for the development of new training materials.

At the completion of the workshop participants will:

- Master the concepts and principles of disease diagnosis, ecology and management;
- Understand how pathogens cause the disease symptoms in plants that can be used to diagnose causal agents;
- Master symptom identification skills;
- Master disease management skills;
- Produce training materials based on learning exercises demonstrated here, including session guides and curriculum, for use within FFS activities;
- Utilization plan developed for how new knowledge gained and skills developed will be employed to strengthen National IPM programme capacity for farmer education on disease management.

The full concept note for the RVDDEM training is given in **Annex 1** while the full programme for the RVDDEM training is given in

Annex 2.

Thirty-nine people were invited to participate in the training, this was made up of:

- 17 international and 12 Cambodian national IPM Trainers
- 5 resources people
- 3 organisers/facilitators
- 2 representatives of the FAO Regional Vegetable IPM Programme.

Participants and resource people came from Vietnam, Thailand, China, Lao PDR, Indonesia, Bangladesh, Nepal, Philippines, Myanmar, Cambodia, The United States of America, The Netherlands and Australia. A full list of participants is given in **Annex 3**.

Section 2 Opening Ceremony

The FAO Regional Disease Diagnosis, Ecology and Management (RVDDEM) Training was officially opened when Mr Chouchey Thyrith, (Cambodia FAO-IPM Programme Coordinator, Ms AlmaLinda (Dada) Abubakar (FAO Programme Development Officer) and Mr Nghin Chhay (Deputy Director DAALI) gave brief speeches welcoming participants and explaining the rationale behind this training event. Participants were requested to share their experiences and to learn from one another and resource people during the RVDDEM. Participants were also asked to keep in mind the need to utilize the knowledge and skills learned during the training once participants had returned to their home countries. The full texts of the above mentioned opening speech and remarks are given in **Annex 4**.

Section 3 Course introduction and Participants' Expectations

The introduction to the RVDDEM highlighted the relevance of this event for trainers working with farmers within IPM systems. Emphasis was placed on early observation and identification of symptoms so that preventative steps to manage the disease could be made before significant crop and yield losses were incurred. During the training programme overview the participants were introduced to the workshop content ie. review of current status in each country (**Section 4** and **Annex 5**), technical presentations (
Section 5), field visits (**Section 6**), practical classroom exercises, group discussions and presentations of field and classroom work (**Section 7**). The objectives of the training were also outlined so that participants knew what –and what not- to expect from this training. These objectives are outlined in **Section 1**

To improve the delivery of the RVDDEM training participants were asked to share their expectations with the organizers. Participants were given pieces of colored paper and asked to write down what they expect during this training. To compliment desirable expectations participants were also asked what they felt was undesirable and did not want to experience during this training. These expectations are summarized in **Table 1**.

Table 1. The following desirable and undesirable expectations were shared by participants.

Desirable	Undesirable
friendship	participants and facilitators speak slowly as English was the 'second language' for most participants
partnership	want to avoid mistakes
smiles	speak and participate even if unsure the answer they provide was correct
cooperation	participants should not be passive
practical exercises and learning	avoid problems
happiness	unhappy participants
sharing of ideas and experiences	unpleasant learning environment
new experiences	smoking
	non-cooperation
	keep to schedule and do not run overtime
	sleepy
	human diseases

Section 4 Country Presentations

Each participating country presented and shared relevant plant disease experiences as well as the current status of disease management issues and national initiatives, including an initial needs assessment for strengthening on-going and to-be-developed disease management activities within the context of local vegetable IPM Programmes. The main aspects of coverage included the background to IPM, the national agricultural system (geography, topography, ecosystems and crops), crops damaged by the major diseases and management methods. Summaries for each of these country presentations are given in **Annex 5**. A list of acronyms and common names for plant diseases is included in **Annex 6.**

Section 5. Technical Presentations by Resource Persons and Participants

Many technical presentations were delivered by specialist resource persons and some of the country participants. To complement power point presentations some presenters distributed handouts to participants, other material was included in the RVDDEM training CD and distributed to participants while a list of reference material that was distributed to participants during the RVDDEM training is detailed in **Annex 7**. Several presentations were also supplemented with practical hands-on exercises that were sourced from various IPM training manuals and participating countries. Overall, a wide range of topics and experiences were covered.

Vital aspects of plant disease diagnosis, ecology and management including the concepts, principles and related theories were dealt with in these presentations. Practical activities that may be utilized as learning activities within FFS were demonstrated. Issues relating to all aspects of nursery and field management as well as the envisaged future prospects for plant resistance and tolerance to disease were also covered. Technical presentations (as well as all the country presentations) were captured in a CD and given to all the participants as reference materials for use once they have returned to their homes. A few, however, were given as printed hand-outs and are not included as an annex in this report.

5.1 Concepts and Principles of Disease Ecology, Diagnosis and Management, Dr Marilyn Patricio

Understanding the concepts and principles of plant disease is pre-requisite in formulating an effective disease management strategy. A disease is a condition when the physical processes of the plant do not function normally. Diseases cause a plant to lose vigor, exhibit reduced growth and fruit development or different colored foliage. Diseases result in an overall

reduction in economic value of the plant. The plant usually produces evidence of disease in the form of "symptoms". These include wilts, spots and death of plants.

Plant diseases are caused by living (biotic) organisms called pathogens. These include fungi, bacteria, viruses and nematodes. The diseases caused by these factors are recognized by their symptoms and signs and can be managed by reducing and destroying the pathogen population.

Fungi are generally microscopic, multi-cellular, non-chlorophyll bearing organisms that produce spores and mycelia. Fungi mostly live on dead organic matter and spread by wind, water, insects, other animals and humans.

Bacteria are unicellular microorganisms that reproduce by binary fission and can be classified by their shape: spherical, rod-shaped, spiral and filament. They are further classified by their reaction to the Gram's stain, either Gram positive or Gram negative. Bacteria may be spread by wind, splashing from irrigation or rain, infected seed or other propagation material. Bacteria gain entry into, or infect, the host through natural pores (e.g stomata) or wounds.

Virus are microscopic, obligatory intracellular organisms that rely on other organisms for their survival and reproduction. They may only be observed with the aid of an electron microscope and either consist of protein and genetic material (viruses) or genetic material with no associated protein (viroids). Viruses infect plants through mechanical wound or may be introduced to the plant via the feeding action of insect carriers known as *vectors.*

Plant pathogenic nematodes are microscopic un-segmented roundworms that possess a spear or spear-like stylet that is used to puncture plant cells. Nematodes have an egg, four larval and an adult life stage. During the second larval stage the stylet is used to infect the host plant. The remaining three molts occur within the host tissue or in the soil. Nematodes may spread passively by water, soil, farm tools, planting stocks, etc.

Plant disease may also be caused by non-living (abiotic) factors recognized as physiological orders. Such abiotic factors may be attributed to the environmental conditions including extreme high and low temperature, moisture excess or deficit, low or intense light, nutrient deficiencies or toxicity, improper cultural practices and unsuitable pH. The diseases caused by these factors are recognized only by their symptoms and can be managed by avoiding the causal environmental factor or by providing the factor that is lacking.

Diseases develop as a product of the combined interactions between the pathogen (virulent causal), the host plant and the environment. These factors combined form what is known as the "disease triangle" or "pathosystem" within the ecosystem. A little amount of disease agent may multiply and become established if the host is very susceptible and the environment (temperature, moisture, humidity, etc) is ideal. A fourth factor, time, can be added to the disease triangle; the "time" component relates to the progression, or spread, of the disease in the population.

Management of diseases relies on the manipulation of one or more factors that make up the triangle. Examples may include avoiding susceptible host plants or selecting resistant varieties, reducing the population of a pathogen by removing the infected plants from the field before planting a new crop (sanitation), using furrow irrigation rather than overhead irrigation where humidity stimulates spore formation and spread of the disease.

Development of disease in a plant goes through series of steps known as the disease cycle. The cycle includes the activities of the pathogen while it is on and within the host as well as those while the pathogen is outside the host. Environmental factors such as temperature, moisture, light, pH, oxygen and carbon dioxide relations may all affect a pathogen during

entry and subsequent infection, colonization and symptom development within the plant. The severity of many diseases is enhanced by extended rainy periods and high temperatures. Heavy and persistent dew during cool weather or frequent rains during hot weather can result in extensive and rapid disease development. When conditions are not favorable for infection during adverse conditions, the pathogens survive as a saprophyte on decaying plant debris or within the soil by forming thick-walled resistant structures. Diseases may also survive in weeds and alternate hosts, within insect vectors or in and on the seed.

The identification of plant diseases, known as “diagnosis”, relies on recognition of characteristic symptoms, signs and other factors. Proper diagnosis is necessary for effective disease management. The process required for successful diagnosis of the causal agent of a disease includes a thorough knowledge of a field’s recent history (planting date, disease history, cultural practices, etc.) disease pattern, causal pathogen by microscopic examination, and consultation on published pictorial guides. Identification of uncommon or unknown diseases should follow rules of proof of pathogenicity, following the Postulates of Koch.

Management of diseases is primarily based on the principles of:

- avoidance of the pathogen;
- eradication of the pathogen;
- protection and
- plant disease resistance.

Avoidance of the pathogen is through judicious selection of suitable fields, disease-free seed and planting materials, and tolerant/resistant varieties. Diseases may also be avoided by modifying cultural practices such as planting times. These measures ensure that contact between the host and the pathogen is avoided, or the susceptible stages of the plant and favorable conditions for pathogen do not coincide.

Exclusion of inoculum by regulatory measures such as quarantine and enforcement of laws that inhibit the import and export of living materials, producing high quality “certified” seeds, and exclusion of insects that transmit certain pathogen can all reduce disease incidence.

Eradication of the pathogen by reducing or eliminating the amount of inoculum in the soil, seed, or alternate host also reduce disease incidence. Cultural practices such as crop rotation, mixed cropping and roguing at the early stage of disease development, field and plant sanitation, soil treatments (thermal), flooding and heat treatment of diseased plants are also effective.

Integrated disease management utilizes a combination of two or more of these control measures to reduce the level of disease to an acceptable level while maintaining the integrity of the environment.

5.2 Bacterial Diseases of Vegetables: Ecology and Identification, Dr Marilyn Patricio

Bacterial diseases are a major constraint to the production of off-season vegetables. In general, plant pathogenic bacteria can be identified using physical characteristics. They may be flagellated, rod-shaped, aerobic or anaerobic, gram-positive or negative and non-spore forming. There are some exceptions such as *Streptomyces* sp. that is filamentous like a mold while their biochemical and physiological properties are characteristic of bacteria. Corynebacterium (cause of canker in tomato) is gram-positive.

There are 29 known genera of plant pathogenic bacteria (Natural, 1999), however only few of these (e.g *Erwinia, Agrobacterium, Pectobacterium, Corynebacterium, Ralstonia, Xanthomonas and Streptomyces* sp.) cause vegetable diseases.

Pathogenic bacteria may spread by a variety of means including wind, splashing from rain or irrigation, use of infected seed and plant materials, man and insects. They gain entry into the host through natural openings (stomata, hydathodes of leaves, lenticels of stems, nectaries, leaf scars, trichomes) or through wounds (root, insect or nematode and cultivation wounds).

Bacterial leaf pathogens usually enter through stomatal openings. The bacteria that cause common bean blight and angular leaf-spot penetrate their hosts through stomata. Rain and water-soaked leaves facilitate the entry of bacteria as there is a continuous column of water from the leaf surface to the sub-stomatal cavity, which allows motile bacteria to "swim" through the stomata to the inside of the plant.

Pectobacterium carotovorum, the causal agent of bacterial soft rot, enters potato tubers through lenticels and through mechanical injuries or wounds. Some bacteria such as *Xanthomonas campestris pv. campestris*, the cause of black rot of crucifers, enter through hydathodes, pores located at leaf margins or tips that give off water during periods of high humidity.

Identification of a disease requires careful study of the characteristic symptoms, signs and other factors related to disease progress. This can be done by direct microscopic examination of infected tissues. To compliment direct examination, diseased tissues may be stained to emphasise identifiable characteristics.

The common symptom caused by bacterial pathogens includes wilts, soft rots, leaf blight/spot/specks, canker, overgrowth and scabs. Diseases can also affect the stem and roots of the plant.

The major bacterial disease problems particularly in off season vegetable production include; bacterial wilt of tomato (*Ralstonia solanacearum*), bacterial leaf blight or black spot of cabbage (*Xanthamonas campestris* pv. *campestris*), bacterial spot of tomato and pepper (*Xanthamonas campestris* pv. *vesicatoria*), bacterial soft rot of vegetables (*Pectobacterium carotovorum* subsp. *carotovorum*) and bulb rot of onion (*Burkholderia cepacia*).

To manage bacterial diseases resistant varieties, grafting using resistant stock, diligent adoption of cultural practices coupled with the use of biocontrol agents, biofumigation and avoidance of chemicals are recommended.

5.3 Viral diseases of vegetables: ecology, early identification and the importance of insects as vectors of viral diseases, with an emphasis on tospovirus, Dr P. Kumar

Vegetable production in the low-land tropics and other parts of the Asia is extremely vulnerable to insect herbivores. Lepidoptera pests are the most common insects causing serious losses to crop yields. However in recent times, sucking insect-pests such as thrips, whiteflies, jassids (hoppers) and mites have emerged as the dominant group of insect pests posing serious challenges to the sustainable production for vegetables. When the population

of sucking pests is low most vegetable crops are able to compensate for the damage caused by insect feeding. However in large numbers, sucking insects impose serious damage such as that caused by red spider mites in eggplant fields in South Asia. More importantly, many sucking insects are able to vector important plant viruses which have recently resulted in smallholder vegetable producers witnessing several fold increases in viral diseases in crops like tomato, beans, etc.

The emergence of viral diseases posses multiple challenges not only for sustainable production but also for the IPM trainers and peoples engaged in developing management strategies for such problems. Considering the difficulty in identifying viruses from their symptoms and the need for sophisticated equipment to observe and identify virus particles (such as electron microscopes) viral diseases are often confused with prevalent micronutrient deficiencies and symptoms of other diseases.

Considering this, working with viral diseases requires not only well-skilled trainers to deal with the life cycle and other important ecological lessons of these vectors but also developing simpler, accurate and faster identification methods. In addition, developing management options for these viruses and their vectors is extremely important for successful vegetable IPM implementation at smallholder farm level in Asia.

In this context, first a general session introduced the various pathogens and covered important aspect of virus ecology as well as general facts and ideas on virus management. Following this, two major practical examples of important insect vectors were given: thrips as vector of tospoviruses and whitefly as vector of Tomato Yellow Leaf Curl virus. Lengthy discussions were held on virus and vector management considering the significant economic importance of viruses in the region. Participant groups were asked to consider one of the following questions:

- What are common and Latin names for viral diseases?
- Why are diseases a serious threat to sustainable vegetable production?
- Why are viruses becoming a serious challenge for vegetable growers in Asia?
- What kinds of tools and techniques are available to the trainers to deal with viral diseases at FFS/ToT and other farmers education process?

Furthermore, hands on exercises on virus transmission and symptom development progressed further into ideas for virus and vector management. Recent scientific advances were also discussed with the participants. It is expected that some of these lessons learned would directly feed into the ongoing training work in the region and to some extent it would inspire trainers to work on viral diseases with more vigor.

5.4 Integrated Disease Management of Bacterial diseases of vegetables, Ms Vale Justo

Integrated Disease Management is the selection, integration and implementation of pest control strategies that are ecologically sound, economically viable and socially acceptable. Disease management strategies are ecosystem focused such that they are sustainable, environment-friendly, cost-effective, economical, practical, flexible and mutually compatible. Disease diagnosis or identification is the basic step in disease management. Some of the tools and methods needed to manage diseases include diagnostic keys, training, monitoring and sampling techniques, accurate methods to determine yield loss and damage as well as predictive systems that allow early intervention to minimize the spread and severity of diseases.

The different strategies for Integrated Disease Management are the following:

- Host plant resistance – Plants have inherent characteristics such as immunity, hypersensitivity, resistance and tolerance against various pathogens. Tolerance and resistance are the common types utilized by plant breeders to develop for resistant varieties of vegetables to specific pathogens or diseases.
- Natural control – Biological control agents such as *Trichoderma harzianum and Bacillus subtilis* are available to control damping off and other soil-borne pathogens.

- Cultural control – Crop sanitation, crop rotation, intercropping, planting trap crop, planting disease-free seeds or planting materials, timing, choice of clean or non-infected areas, sanitation, weed-free areas, proper water and fertilizer application, use of organic fertilizer, proper plant spacing, thorough land preparation, liming, raising beds, staking or trellising and biofumigation are among the measures that will help reduce or prevent disease infection in vegetables.
- Physical and mechanical control – The use of heat, physical barriers such as screen or nets to keep out insect vectors, plastic mulch reduce disease infection in the field.
- Preventive measures – Quarantine regulations and proper implementation prevent the establishment of new pests or limit its spread in the area.
- Chemical control – Need-based application of fungicides is necessary to eradicate pathogens or protect the spread of the disease in the field and in the neighboring areas.
- Biotechnology – Improvement of the genetic characteristics of the plant to develop a more tolerant or resistant, good quality and high yielding variety such as transgenic plants and tissue culture is the new trends in agriculture.

5.5 Nematodes: concepts and principles of disease ecology, symptom identification and management, Dr Pyone Pyone Kyi

Dr Pyone gave a comprehensive presentation that highlighted the signs and symptoms of plant diseases caused by plant-parasitic nematodes (PPN). Dr Pyone explained symptoms observed in the field are very difficult to differentiate between damage symptoms caused by PPN, other diseases and nutrient deficiency symptoms. When inspecting plants for damage symptoms caused by PPN observers should consider above and below ground parts plants.

Dr Pyone then described how to sample for PPN in a range of annual or perennial crops, soil types, cropping systems considering the species of nematode. Samples should be taken from the root zone where there most fibrous roots are present. The depth will rely on the roots and the species of nematode. Important points to consider are included in **Table 2**.

Table 2 Important considerations when sampling for nematodes

Collecting appropriate substrate	soil, roots, tubers, leaves, seeds
Sampling tools include	soil auger, trowel and a spade
Sample size	100g up to 2 kg (depending on level of accuracy required)
Sampling depth	20 cm for most crops, 15 – 100 cm for deep-rooted perennials, 8 – 12 cm for shallow-rooted, 30 – 45 cm for hot/dry regions
Time of sampling	It is best to sample at the stage of active root growth
Sampling Pattern	Divide large fields into 1 acre unit and collect samples at equally-spaced intervals across the field When crops are planted in rows collect samples from along the rows in the root zone ~10-20 cm from the stem. Collect roots of crop plants, weeds and volunteer crop plants. Closely observe patches of poor plant growth and borders showing disease symptoms. Compare these areas to others without When inspecting orchards sample trees along the drip line, on alternate sides of the trunks, and include feeder roots, weeds and

	volunteer crop plants.
Handling and preserving samples	Clearly labeled, kept cool, record valuable information, (name of grower /collector, locality, standing crop, symptoms, date variety of crop, crop rotation, nematicides used) Strong bags that can be closed tightly as to avoid loss of soil humidity, separate above-ground plant materials from roots covered with soil Process within a week of collection

Techniques used to isolate PPN were also described. The important point to consider is that the sample should be processed as soon as possible after collection. From each soil sample two basic techniques can be used to extract PPN:

- Active extraction: where the nematodes are able to move from the soil;
- Passive extraction: where they are separated from the soil by physical means such as elutriation or sieving (sedentary nematode).

Nematodes may also be extracted from plants or plant tissues or may simply be stained and observed *in-situ*. Preservation techniques were also covered including descriptions on methods to kill, fix, and mount nematodes and plant tissues such as roots and stems.

Unfortunately laboratory equipment capable of allowing participants to identify different species of nematodes was not available for the training. However, recognizable taxonomic differences between plant-parasitic nematodes and free-living (nonparasitic) nematodes were given. Plant parasitic nematodes were divided into different groups based on their biology and mode of feeding.

A review of nematode management techniques highlighted the need to correctly diagnose nematode related problems and determine whether populations are high enough to threaten the crop.

Participants were reminded to take soil samples during warm weather and when plants are in the growth stage. This is particularly important for root knot nematodes, the most common PPN. These nematodes are unable to penetrate roots when soil temperatures are < 50˚F, and will not reproduce when soil temperatures are below 58˚F.

During discussions on managing PPN it was recommended farmers select nematode resistant variety incorporated with cultural and biological practices, relying on chemicals (nematicides) as a last resort.

5.6 Fungal Diseases of Vegetables: Ecology and Identification, Dr Lowell Black

PowerPoint presentations on fungal diseases of cucurbit crops, crucifer crops, pepper, tomato, and onion with emphasis on lowland tropical production were prepared and presented to workshop participants. The more common and economically important diseases of these crops were covered in the presentations that included photographs of disease symptoms, diagnostic morphological characteristics of fungal pathogens, a description of disease symptoms, conditions for disease development, and control measures. To supplement the presentations, a book entitled 'Vegetable Diseases – A Practical Guide' with color photographs depicting disease symptoms was distributed to the participants. The book covers identification and management of bacterial, fungal, nematode, viral, and physiological diseases of cucurbits, crucifers, pepper, and tomato. Hopefully, it will be a useful reference to participants in future training activities and in making diagnoses and disease management recommendations after returning to their respective duty stations.

Tissue scraped from lesions was microscopically observed in water mounts for fungal structures to confirm diagnosis of some of the disease samples used in the workshop.

The workshop enhanced participant awareness and knowledge of vegetable diseases, disease symptoms, pathogen dissemination, conditions for disease development, and some available control measures. The enthusiasm and desire to learn demonstrated by the participants was remarkable. This experience undoubtedly will be an asset to them in the future as they prepare for and conduct farmer field schools on disease identification and management. Accurate disease diagnosis, a prerequisite for management, requires extensive training and practice. The workshop provided a good starting point, however, it did not turn out trained diagnosticians nor was it expected to do so. The next step is for trainers and government officials responsible for disease diagnoses to receive more detailed training and have access to laboratories with reference materials, microscopes, microbial culturing facilities, and viral test kits. In the long term, local scientists with graduate degrees specializing in plant pathology, plant protection, or pest management will be needed to advance the field of disease diagnosis and management within several of the countries represented in this workshop. To reach this point will take time and resources, but in Dr. Black's view will be necessary for them to become self sufficient in disease diagnosis and to develop safe, reliable, and economic disease management practices applicable to their specific locations.

Section 6 Field Visits

All of the field visits made during the RVDDEM training provided practical activities both when in the field and once participants had returned to the meeting room. To this end much of the information in **Section 6** is complimentary to the practical activities described in **Section 7.**

6.1 Collecting diseased plant specimens

As part of the RVDDEM training participants made visits to farmers' fields so that they could interact with farmers, and observe and collect specimens of various plant diseases. These field visits allowed participants the opportunity to closely observe crop management and protection practices in Cambodia and consider the operational constraints related to managing disease problems in the field. Field visits were made on three different days. During the first two days participants were divided into two groups which then visited two different fields. All participants visited a post-FFS activity during the third and final field visit.

Prior to visiting these fields participants were introduced to the objectives of the field visit and asked to consider the following issues when collecting background information about crop and disease management:

- Are there signs of diseases? What are the symptoms?
- In what part of the plant did change occur?
- At what growth stage did the problem occur?
- What variety is severely affected?
- Does the disease affect the entire field? In cluster or individual plant?
- Is the soil properly fertilized?
- How is the drainage condition?
- Was the field properly prepared?

Diseased plant samples were collected for observation and discussion during afternoon sessions. Diseased plants were used to prepare inoculations according to the techniques described in **Section 7**.

6.2 Museum trip

In the early morning of day seven participants briefly visited the National Museum to observe preserved artifacts and different aspects of Khmer culture.

6.3 Srer Spey village post-FFS

Following an early departure participants made the final field visit to a post-FFS activity in Srer Spey village, Kong Chey commune, Ov Raing Ouv district, Kampong Cham. Many practical activities were conducted during this visit.

The visit began with farmers and trainers introducing the objectives of the post-FFS activity to RVDDEM participants. Here, farmers are conducting a field school that compares three varieties of tomato for disease resistance in one activity and compares treatments for damping off management in a seedbed and bacteria wilt management treatments in the field in other activities. Participants were able to discuss the activity directly with farmers while farmers were able to interact closely with participants and resource people and participate when biofumigation and biological soil disinfection treatments were prepared.

A summary of the farmers' report of the field activities includes:

- Mongal variety has a higher tolerance to TYLCV and Bacteria Wilt, along with higher yield and more marketable fruit, than the other two varieties produced at Kbal Koh vegetable research station.
- The seedbed treatments showed that burning a 20cm thick layer of rice husk on top of soil before planting seeds provided higher survival than the application of lime or the incorporation of brassica tissue in the treatment known as biofumigation.
- There was no clear difference between treatments designed to manage bacteria wilt in the field.

Farmers also demonstrated the vascular flow test, a technique to identify bacteria wilt infected plants as well as a disease zoo that demonstrates the transmission of TYLCV by its whitefly vector. Thirteen days after whitefly vectors were introduced TYLCV symptoms were observed in the tomato plants.

The final activity involved the preparation of biofumigation and biological soil disinfection treatments. Following an introduction to the treatments participants and farmers prepared the field, chopped plant material and incorporated the green matter into the plots.

The discussions following each session provided valuable opportunity for farmers and participants to explore the activities in greater detail. Selected photos of all these field activities are included in the CD distributed to participants.

Section 7. Practical Activities

All field visits and lectures were supplemented with practical exercises to provide participants hands-on discovery learning opportunities surveying fields to collect cropping information and observe disease symptoms. The following exercises in the meeting room helped to identify the causative pathogen. The practical activities undertaken during the final field visit to the post-FFS activity in Srer Spey Village are detailed in **Section 6.**

Disease inoculum for four pathogens was prepared and participants successfully completed exercises whereby pathogens or insect vectors were transferred from diseased to healthy plants. These activities not only allowed the observation of disease symptoms and their development but also provided an opportunity to practice exercises that may be conducted with trainers and farmers once participants have returned to their respective countries. Following all these activities participants prepared training curricula and made presentations of their activities. Outlines of these practical activities are as given.

7.1 Classification and identification of disease symptoms found in the field

Following field visits participants returned to the meeting room to observe and classify the samples, making drawings of disease symptoms and describing the general appearance of roots, stems, leaves, flowers and fruit. The groups then made presentations of their findings and answered questions. Photographs of participants taken during field visits, classroom activities and while making presentations are included in the RVDDEM Training CD.

7.2 Transferring inoculum from diseased to healthy plants

In a complimentary exercise to **7.1** participants transferred infective propagules of fungal and bacterial pathogens from diseased to healthy plants to allow observations of symptom development to be made. The objective of this exercise was to highlight aspects of disease ecology and demonstrate how diseases develop in plants. **Table 3** describes how inoculum was prepared and what method was used to inoculate plants while **Table 4** gives a summary of observations made by RVDDEM training participants.

Table 3 Inoculum preparation technique for transferring disease to enable observations of symptom development

Vegetable	Pathogen	Inoculum preparation	Inoculation procedure
Cauliflower	Bacterial soft rot	Diseased cauliflower flowers were suspended in water overnight so bacteria streamed from the cut stem.	1ml of the resulting inoculum was injected into the cauliflower stem
Tomato	Fungal blight	Diseased leaves were placed in a plastic bag containing moist tissue paper before being sealed and left to sporulate over night.	This inoculum was either swabbed or transferred to a small hand sprayer and misted onto the underside of the leaves.
Onion	Leaf spot	Diseased onion leaves were placed in a plastic container containing moist tissue paper, sealed and left overnight to sporulate	Inoculum was transferred to a small hand sprayer and misted over plants.
Cucumber	Downy mildew	Diseased cucumber leaves were placed in plastic bags containing moist tissue paper, sealed and left overnight to sporulate	This inoculum was either swabbed or transferred to a small hand sprayer and misted onto the upper and lower side of healthy leaves.

Table 4 Summary of disease development observations.

	Enclosed within plastic bag			Without plastic bag			Control		
	1 DAI* (Sep 24)	**2 DAI (Sep 25)**	**4 DAI (Sep 27)**	**1 DAI (Sep 24)**	**2 DAI (Sep 25)**	**4 DAI (Sep 27)**	**1 DAI (Sep 24)**	**2 DAI (Sep 25)**	**4 DAI (Sep 27)**
Cauliflower	No change	Leaves yellowing between veins, dark shadows on petiole, midribs and stem	Entire leaf is yellow, starting to rot	No change	Shaddow on stem, stem rot symptoms developing, stem broken at point of infection	Spots on leaves	No change	Few small white spots	Several white spots on leaves
Onion	No change	Leaves yellowing	Leaves beginning to turn yellow or black, and rotting	Small white spots, leaves beginning to curl	More small white or yellow spots	Yellow leaves drying	No change	Leaf tip becoming white and curled	Tips becoming yellow, dry
Cucumber	Small brown lesions underside leaves, edges of leaves yellowing	More lesions, edges of leaves becoming brown, dry	Yellowing of leaves from centre, rotting and necrosis	No change	Veins becoming darker, watery lesions developing	Watery lesions	No change	No change	Leaves dry between veins, some grey spots
Tomato	No change	Small dark spots on underside of leaves	Stem is rotten, dark spots on leaves	No change	Small black spots starting to develop on leaves	Large dark spots on yellowing leaves	No change	Dark spots developing on leaves	Several developing on leaves

*DAI – Day/s After Inoculation

7.3 Insect vectors in disease zoos

The role insect vectors play in spreading disease was emphasised during Dr Kumar's presentations covering viral diagnosis, ecology and management. To provide hands on experience and allow participants to gain a deeper understanding of viral transmission disease zoos were prepared focusing on two important vectors, aphids and thrips. Participants discussed aspects of insect biology to identify where on the plant insects can be found before transferring insects from diseased plants to healthy plants. Participants then prepared a summary of this activity that can be implemented in field schools to demonstrate viral transmission to farmers.

7.4 Milk to reduce transfer of virus

Although there is still debate over the effectiveness of this treatment, many researchers recommend the use of milk to reduce the spread of virus particles between plants. Techniques using milk are frequently used in nurseries to stop the spread of virus between susceptible hosts when people touch the plant, for example during pruning.

The reason milk is used is that milk has a protein called casein. When the virus comes in contact with milk the casein inactivates the protein capsid of the virus. The method to prepare this treatment is to mix 100g of skim milk with 1000mL of water and 50mL Dettol. Fingers and tools are soaked in this when moving from one plant to the next.

7.5 Extracting nematodes from soil

Dr Pyone demonstrated a simple technique of sampling soil for nematodes. This required soil to be collected from the root zone of plants showing disease symptoms and spread over a fine mesh gauze that is suspended above a shallow reservoir containing water. Over approximately 24 hours the nematodes move out of the soil and down into the reservoir where they can be counted. A more detailed description of such techniques is given in Dr Pyone's presentations included in the CD distributed to all participants.

Section 8 Panel Discussion

A Panel Discussion elaborated on the workshop content and provided participants an opportunity to ask questions and clarify topics covered during the workshop. The panel composed of Mr. Jan Willem Ketelaar, Dr. Lowell Black, Dr. Marilyn Patricio, Ms. Valeriana Justo and Dr Probhat Kumar.

Topics covered during the pane discussion included:

- Respective roles of government and private sector with regards to strengthening disease management;
- Will FAO provide funding for the strategic plans formulated as part of follow up to this workshop?
- What is the minimum area for setting up field experiment? How can an experiment be done in scientific way?
- How can biofumgation be performed? How much does biofumigation increase disease management? Which crops can be used for biofumigation?
- How does ITC control/suppress BW in the soil?
- What species of whitefly are important vector for virus transmission?
- Are bio-pesticides for whitefly control available? What can farmers do if their crop is infected with virus?
- How do we reduce or manage stem rot and blight disease in watermelon and cabbage?
- How do we diagnose early a virus disease in the field?
- How can male and female nematodes be distinguished?

- Why use transparent plastic for fumigation? How does mulching with plastic cover affect biodiversity and populations of beneficial microorganisms?

Section 9 Curriculum/Session Guides, Formulation of National Vegetable Disease Management Strategies

9.1 Curriculum and session guide

All of the activities conducted during the RVDDEM training can be adapted and incorporated within field school curricula in respective countries. These activities were practiced during the workshop and included in the workshop manual and other written resource materials distributed to participants. Furthermore session guides including activities utilizing biofumigation for the treatment of soil-borne pathogens as well as exercises that demonstrate how disease can be transferred by the feeding action of insect vectors including thrips, aphids and whitefly were shared with participants.

9.2 Country Strategy plans

Country strategies that focus on vegetable disease diagnosis, ecology and management plans were prepared by participants to identify how best to strengthen disease related farmer training and action research within the context of their respective national IPM programmes. Participants were asked to form country groups when preparing the following information: title, background (explaining the issues and need for project), objectives (of the project), activities (procedures on how to carry out the project activities), expected output (who and how farmers and technical staff will benefit from the proposal), materials (needed to carry out the activities), target date and duration, and a budget (to carry out the project, with indication of any external support where needed).

Participants were given several opportunities to consider this country strategy during the workshop and asked to pursue the matter further in their own time before each country draft proposal was presented and discussed, and suggestions were made on how improvements can be made. Upon their return, participants are expected to revise their respective proposals and submit them for local or external funding support. The proposed topics for some of the countries represented during the RVDDEM training are as follows:

Bangladesh: Developing capacity of IPM trainers on vegetable disease diagnosis, ecology and management
China: Strengthening IPM awareness with farmers, trainers and the private sector.
Cambodia: National Vegetable Disease Identification, Ecology and Management Training
Indonesia: Sharing biological management techniques for soil borne diseases with FFS, Alumni FFS TOT and farmers.
Laos: Promoting biological soil management in IPM training.
Nepal: Utilization of disease identification, ecology and management techniques through workshops and training within ToT, FFS and Field studies
Philippines: Biological solutions to disease management to develop biologically sound agricultural practices.
Thailand: Refresher Training focusing on disease diagnosis, disease ecology and management
Viet Nam: Strengthening vegetable disease management through training and field studies.

Section 10 Evaluation of the RVDDEM Training

On day four of the training participants were asked to identify the strengths, the areas that could be improved and suggest ways such the training could be strengthened if it was done again. These suggestions are detailed in **Table 5**.

Table 5 Mid-term workshop evaluation

Strengths	Areas that could be improved	Suggestions
Activities on time Good organisation (sufficient teaching material) Good training environment Good cooperation Opportunity to share experiences from different countries Relationships with other participants Very participatory Highly practical content Activities highly relevant to work Learn new information and skills	Audio visual materials lacking All participants and facilitators should speak slowly and clearly More ice-breaking and group dynamics needed	Tour programme should be arranged More relaxation Visiting Angkor Wat Visit of IPM field school (running)

At the conclusion of the workshop participants were again asked to evaluate the training so that improvements can be made in the organization of future training activities. The results of this survey are detailed in **Table 6**.

Table 6 Final workshop evaluation

Completing the workshop:	Disagree (%)	Unsure (%)	Agree (%)
Has improved my understanding of disease diagnosis	0	11.5	88.4
Has improved my understanding of disease ecology	0	7.7	92.3
Has improved my understanding of disease management	0	15.3	84.6
Will help me improve my skills in recognizing disease symptoms and causative agents	0	19.2	80.7
Will help me improve my disease management skills	0	3.8	96.2
Has been a worthwhile investment of my time	0	11.5	88.5

Some comments:

Is the workshop material provided a useful reference?

- More symptom identification information and methods to slow disease spread;
- More information on how to train farmers and improve their understanding of IPM;
- Provide a CD with all workshop proceedings;
- Include results from disease management studies;
- Include more information on Nematode identification;
- Need color photos;
- More information on methods for setting up disease zoos for working with farmers.

When asked how this training will enhance their knowledge and benefit field activities in the respective country IPM programs, participant responses included:

- All activities, especially disease diagnosis and management sections as well as insect vector studies, will be incorporated in training curricula
- Organise national disease workshops to share knowledge and techniques with IPM trainers;
- Will use knowledge to develop country strategic plans;
- Information on nematodes is very useful.

Overall there were favorable comments by the participants in terms of organisation, training facilities, facilitators, resource people and practical activities. Participants would have liked a longer workshop overall and although participants found the theory and practical sessions regarding nematodes useful they would have like to have greater opportunity to discuss and conduct practical exercises. Finally, participants suggested better field and laboratory equipment to assist in observing and diagnosing specimens.

Section 11 Closing ceremony

An important event of the Closing Ceremony was the awarding of certificates to the participants for completing the RTBC. The certificates were officially handed over by both HE. Koum Saron (Director General of MAFF), Ms. Kimiko Uno (FAO Representative for Cambodia) and Mr. Jan Willem Ketelaar (CTA, FAO Vegetable IPM Programme). HE. Koum Saron and Ms. Kimiko Uno then delivered closing remarks in which participants were urged to form a network to facilitate knowledge exchange among the participants and researchers in National IPM Programme. This to help everyone improve disease diagnosis, ecology and management capacities to achieve the common goals of protecting the environment and producing clean food for consumption. **Annex 8** contains the full text of the FAOR speech. Finally, participants were welcomed to enjoy the evening's dinner party before declaring the RVDDEM Training closed.

Section 12 Acknowledgements

Sincere thanks are due to the many people (too many for individual mentioning) who have contributed to the success of the RVDDEM Training. In particular:

- Participants of the RVDDEM Training;
- All landowners and farmers in Kandal province who were visited during the training to observe, collect and discuss disease management;
- Special thanks goes to District Trainers and farmers conducting the post-FFS in Srer Spey Village Kampong Cham Province for their preparation and attention to detail with the extra activities that were setup specifically for the RVDDEM Training;
- All the people and companies who provided accommodation, transport and food to RVDDEM participants ;
- The PDO and CTA, FAO Vegetable IPM Programme, and staff at FAO RAP (Bangkok) for all support necessary in making the RVDDEM Training feasible; And,
- The organizing and management team for planning the RVDDEM, and together with other support helpers, for ensuring that all the RVDDEM expectations are met, including the smooth day-to-day operational execution of the training and related miscellaneous activities.

Annex 1 Concept Note for the Regional Vegetable Disease Diagnosis, Ecology & Management Training Phnom Penh, Cambodia, 20-28 September 2007.

Background Information and Rationale:
Integrated Pest Management (IPM) is a multifaceted, ecologically based strategy that relies on close observation and monitoring of a crop before making management decisions. IPM combines a number of techniques to effectively suppress plant diseases and insect pests in an economically and environmentally conscious manner. Utilizing IPM to manage plant diseases relies on an understanding of disease ecology, symptom diagnosis and management techniques.

Considerable efforts have been made to improve farmer understanding of pest insect management techniques within IPM systems. However, there is still considerable scope for progress to be made with regards to capacity building for effectively dealing with major vegetable disease problems, particularly for off-season vegetable production in the tropical lowlands. The emerging challenges insect vectored viruses pose to many South East Asian countries will also be reviewed during this workshop.

Developing a greater understanding of vegetable diseases diagnosis, ecology and their management will strengthen the IPM farmer education work implemented by the FAO supported National IPM Programme in the Asia region. To this end, FAO and the Cambodian National IPM Programme will convene a Regional Training on Vegetable Disease Diagnosis, Ecology and Management.

Training Objectives:
This training aims to provide IPM facilitators with information and practical training on the principles of disease management (bacteria, fungi, virus, and nematodes) in the Solanaceae, Leguminaceae and Brassicaceae and Cucurbitaceae crop families. This training experience will provide an opportunity to review disease management principles, discuss and share local experiences, undertake practical activities to further develop understanding of disease physiology, improve disease symptom diagnosis and management and develop training materials and curriculum that can be incorporated into FFS and FFS follow up training activities. Specific training objectives include:

- Review concepts and principles of disease management within IPM farming systems, with a focus on off-season vegetable production for the tropical lowlands;
- Exchange knowledge and experiences on disease management strategies within IPM programmes in the home countries of participants;
- Participate in practical activities to develop greater understanding of how diseases damage plant;
- Improve disease symptom diagnosis and management skills;
- Learn more about the latest developments in vegetable disease managements, including innovations developed by both the public/private sector;
- Formulate utilizations plans for how new knowledge gained and skills developed can be utilized, including for the development of new training materials .

Expected Outcome:
At the completion of the workshop participants will:

- Master the concepts and principles of disease diagnosis, ecology and management;
- Understand how pathogens cause the disease symptoms in plants that can be used to diagnose causal agents;
- Master symptom identification skills;

- Master disease management skills;
- Produce training materials based on exercises demonstrated here, including session guides and curriculum, for use within FFS activities;
- Utilization plan developed for how new knowledge gained and skills developed will be employed to strengthen National IPM programme capacity for farmer education on disease management.

Programme Structure:
Workshop components:

- Review disease management activities in SEA countries;
- Review concepts and principles of disease ecology;
- Presentations on the latest developments in vegetable disease management;
- Conduct plant dissections to observe internal damage cause by pathogens;
- Conduct small experiments to assess transfer of diseases between plants and from vectors to plants;
- Field visits to observe disease symptoms and practical exercise to develop diagnostic skills;
- Field visits to observe and practice disease management techniques.

Training Methodology and Activities:
The training methodology and activities employed during this workshop will require active participation in lectures and discussions as well as laboratory and field exercises.

Resource Persons:

- Dr Marilyn Patricio, Central Luzon State University, The Philippines
- Ms Valeriana Justo, National Crop Protection Center, University of The Philippines
- Dr Pyone Pyone Kyi, Plant Pathology Section, Plant Protection Division, Myanmar
- Dr Lowell Black, Seminis Seed Company (formerly AVRDC)
- Dr Prabat Kumar, Rajendra Agriculture University, India

Organisation/Management Team:
The Cambodian National IPM Team will facilitate the organisation of this workshop in collaboration with the following consultants:

- Ms Tattanakorn Moekchantuk, FAO Thailand
- Mr Chouchey Thyrith, National IPM Programme, Cambodia
- Mr Damien Cupitt, National IPM Programme, Cambodia

Participants:
Twenty-nine participants were invited from the Country offices of the FAO Regional Vegetable IPM Programme in South East Asia. These participants are technical officers involved in day-to-day management of FFS and Post-FFS vegetable IPM activities.

3 each from Laos, Vietnam, Thailand and China
6 central team staff and 6 DT's from Cambodia
2 from Bangladesh
1 from Indonesia
2 from Philippines
1 from Nepal

Language Requirement:
The workshop and materials will be delivered in English and thus require participants to possess a substantial degree of English proficiency.

Cost of Participation:
All expenses will be covered by the FAO Regional Vegetable IPM Programme (GCP/RAS/209/NOR). The Cambodian Department of Agriculture, Agronomy and Land Improvement will make available meeting rooms and field equipment and resource persons to facilitate the organization and implementation of the workshop.

Location and Duration:
The workshop will be conducted over eight days at three locations, theory in Phnom Penh, field visit to collect samples at Kandal Province and visit post-FFS in Kampong Cham Province (one day only)

Preparation:
Participants from each country are expected to prepare a short presentation (30 minutes including questions and discussion) of disease management techniques and activities in each country. This presentation will include:

- Outline of the country's major vegetable crops;
- The major diseases that limit vegetable production;
- Techniques and strategies that are utilised to manage those diseases;
- Particular needs identified for strengthening curriculum development and training on vegetable disease management.

Annex 2 Schedule for RVDDEM

Date	Time	Activity	Venue	Facilitator / resource person
Wednesday 19/09/2007		Arrive and check into hotel	Goldiana hotel	
Thursday 20/09/2007	8:00 am	Opening Ceremony Mr Ngin Chhay, Ms Alma Linda Morales, Mr Chouchey Thyrith Course Introduction Participants expectations Form groups Morning Tea Regional experiences in biological disease control: Country presentations Vietnam Thailand Philippines Nepal Lao PDR	Goldiana Hotel DALLI Meeting Room	Damien Damien Tim Tim Vale
	1:30 pm	Country Presentations Indonesia China Cambodia	DALLI Meeting Room	Damien
	3:00 pm	Concepts and principles of disease diagnosis ecology, and management.		Marilyn
	5:00 pm	Introduce field visit		Thyrith
	6:00 pm	Welcome Party		
Friday 21/09/2007	7:00 - 11:00 am	Field visits Objective: observe and collect samples of diseases in Allium and Legume crops	Sdaov Kanleng Village, Day Eth Commune	National Team

Date	Time	Activity	Venue	Facilitator / resource person
		Group 1. Yard long bean Group 2. Onion	Preah Khmer Village Saang District Kandal province	Vale and Damien Marilyn Tim Thyrith
	1:30 pm	Grouping Pathogens Prepare YLB and Allium disease samples to observe disease symptoms over following days.	DAALI meeting room	Damien Marilyn Vale
Saturday 22/09/2007	7:30 – 11:00 am	Field visit in groups Objective: observe and collect samples of diseases in Cucurbit and Cruciferaceae crops Group 1. Cucumber Group 2 Cauliflower	Sdaov Kanleng Village, Day Eth Commune Kandal Province	National Team Marilyn, Damien Vale, Tim, Thyrith
	1:30 pm 3:30pm	Prepare Cucurbit and Crucifer disease samples to observe disease symptoms over following days Preparation for discussion and presentation of observations and experiment design. Group discussions and presentations.		Damien Marilyn Vale
Sunday 23/09/2007	9:00 am	Inoculating tomato, cucumber, cauliflower and onion crops.	DAALI meeting room	Damien Vale Marilyn
	12:00 pm	Free time to visit cultural sites of Phnom Penh		
Monday 24/09/2007	8:00 am 8:15 am 9:45 am 10:00 am	Review Viral diseases of vegetables: Ecology and identification Review resource material for distribution to participants Emerging threats to vegetable production Tospoviruses	DAALI meeting room	 Kumar Kumar
	1:30 pm 3:00 pm 3:15 pm 3:45 pm 4:15 pm	Discussion / activities on viral disease: identification of vectors and host crops/weeds Disease zoo: insect vectors of virus: thrips Break Observe / draw disease symptoms in groups, Onion Cucumber Yard long bean Cauliflower Cultural viral protection: Milk Technology: Demonstration to protect plants from viral pathogens Country strategy discussion	DAALI meeting room	Kumar Oud Treeoat
Tuesday 25/07/2007	8:00 am 8:15 am	Review Bacterial Diseases of Vegetables: Ecology and Identification	DAALI meeting room	 Marilyn Vale

Date	Time	Activity	Venue	Facilitator / resource person
	10:00 am	Integrated Disease Management of Bacterial diseases of vegetables		
	1:30 pm 3:00 pm	Diseases related to Nematodes: concepts and principles of disease ecology, symptoms identification and management strategies in respect to nematodes. Observe symptoms from group work, Onion Cucumber Yard long bean Cauliflower	DAALI meeting room	Dr Pyone Kyi National Team
Wednesday 26/09/2007	7:00 am 9:00 am	Depart Phnom Penh Visit post-FFS Activities: Field observation disease and insects post-ffs. Seedbed treatments for damping off management. Tomato bacterial wilt: diagnosing bacteria wilt, transmission. TYLCV symptoms. Survey for alternate hosts and disease prevention and management strategies - Discussion.	Srey Spey Village O'Rang Ov District Kampong Cham Province	Navuth Kumar Vale Marilyn National Team
	2:00 pm	Visit post-FFS Tomato disease management, biofumigation and BSD treatments in field.	Srer Spey Village,	Navuth Kumar Vale Marilyn National Team
Thursday 27/09/2007	8:00 am 10:00	Fungal diseases of vegetables: ecology and identification: Latest developments in vegetable disease management options, disease resistance development	DAALI Meeting room	Lowell
	1:30 pm 3:00 pm	Observe symptoms from group work, Onion Cucumber Yard long bean Cauliflower Presentations of symptom development from participants	DAALI meeting room	National Team Resource People
Friday 28/09/2007	8:00 am	Panel Discussion: Disease management strategies, Future innovations in disease management	DAALI meeting room	Vale Kumar Marilyn Lowell Jan
	1:30 pm 4:00 pm 4:30 pm 5:00 pm	Designing experiments/training materials Presentations/discussion on utilization plans Workshop review Closing comments Farewell dinner and boat cruise on Mekong River	DAALI meeting room Riverfront	

Annex 3 List of Participants, Resource Persons and Facilitators for the Regional Disease, Ecology and Management Training

Participants	Name	Organization	Phone number	Email address
Cambodia	1. Ms. Srun Khema	FAO-IPM	+855 123 447 84	faoipm.natstaff@online.com.kh
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		Genuine Seed Company		
Vietnam	21. Ms. Nguyen Hong Thuy 22. Mr. Le Quoc Cuong 23. Mr. Lai The Hung	Hai Phong PPSD Tien Giang RPPC(SRPPC) Lam Dong PPSD	+849 144 168 29 +849 181 112 28 +849 157 839 88	ppdhp2003@yahoo.com nguyenhongthuy@haiphong.gov.vn lqcuong1960@yahoo.com.vn the_hung649@yahoo.com
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Resource persons and facilitator	30. Mrs. Valeriana Justo 31. Dr. Lowell Black 32. Dr. Prabhat Kumar 33. Dr. Marilyn Patricio	NCPSC, Laguna Philippines Seminis Seed Company Rajendra Agriculture University Central Luzon State University		vjusto@laguna.net Lowell.Black@seminis.com prabhat@hotmail.com mgpatricio_clsu@yahoo.com

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Annex 4. Opening remarks for the Regional Vegetable Disease Diagnosis, Ecology and Management Training

4.1 Welcome remarks by the Cambodian IPM Project Coordinator Mr ChouChey Thyrith

- Respected Delegation;
- Deputy Director of DAALI and National IPM Programme Coordinator;
- Representatives of Regional FAO IPM Programme;
- Resource Persons;
- Participants.

On this auspicious occasion, it is my great pleasure to be here at the opening ceremony of the Regional Disease Identification, Ecology and Management Training Workshop. On behalf of the Cambodian National IPM Programme of Department of Agronomy and Agriculture Land Improvement (DAALI), the Ministry of Agriculture Forestry and Fisheries (MAFF) and the Royal Government of Cambodia, I would like to extend warm welcome to all participants and resource persons to the Regional Training Workshop on Diseases Identification, Ecology and Management. The National IPM Programme is pleased to host this very important activity. This activity is organized in support of farmer training Programmes in member countries as well as observer countries of the FAO Regional Vegetable IPM Programme. We are happy to see all of you here in Cambodia. We hope that you will learn much from the workshop. Please feel free to approach any of the National IPM Team for any assistance. We wish you an enjoyable stay in Cambodia and success in the workshop.

4.2 Welcome remarks by the FAO IPM Programme Development Officer, Ms AlmaLinda (Dada) Morales

On behalf of the FAO Regional Vegetable IPM Programme, I would like to welcome all of you to this Workshop on Disease Diagnosis, Ecology and Management. I am very pleased to see old friends and meet new friends on this occasion.

This Regional Workshop on Disease Diagnosis, Ecology and Management is organized because we realize the need to develop capacities to deal with major vegetable disease problems, especially in the off-season vegetables in tropical lowlands. We recognize that developing a greater understanding of vegetable disease ecology and management will allow IPM trainers to strengthen their farmer education Programmes. This training aims to provide IPM facilitators with information and practical training on the principles of disease management (bacteria, fungi, virus, nematodes) in the solanaceous, legumes and brassica families. The training will be a review of disease management principles, sharing of local experiences, participants will have practical experience, and develop training exercises and curriculum for FFS and follow-up activities.

We have invited resource persons from different countries with extensive experiences including Dr. Marilyn Patricio from the Central Luzon State University, Philippines and Ms. Vale Justo from the National Crop Protection Center, Philippines. They will be joined later during the workshop by Dr. Lowell Black, formerly with AVRDC, Dr. Prabhat Kumar, formerly from the Asian Institute of Technology and Ms. Pyone Pyone Kyi from the Ministry of Agriculture and Irrigation of Myanmar.

The training is organized by the Cambodia National IPM team supported by Damien Cupitt and the assistance of Tim Moekchantuk. The team has worked very hard to prepare for this workshop. The countries represented in the workshop are Cambodia, China PR, Lao PDR and Vietnam in the Greater Mekong Sub-region as well as observer countries like Bangladesh,

Indonesia, Philippines, Nepal and Thailand. The activity is in line with the FAO Regional Vegetable IPM Programme's commitment to the continued development of IPM Programmes, trainers and farmers.

I wish you all good luck and the success of this workshop. I encourage participants to learn as much from the sessions and the practicum as well as from interactions outside of the sessions. Enjoy your stay in Cambodia!

4.3 Opening Remark by the Deputy Director of DAALI of MAFF

- Honorable Guests,
- Representatives of Regional FAO IPM Programme,
- Resource Persons,
- Participants,

On this auspicious occasion, on behalf of the Department of Agronomy and Agricultural Land Improvement (DAALI) of the Ministry of Agriculture, Forestry and Fisheries (MAFF), it is a great pleasure for me to be here at the opening ceremony of the Regional Training Workshop on Disease Diagnosis, Ecology and Management jointly organized by the National IPM Programme and Regional FAO IPM Programme today. I am pleased to express my warm welcome to all delegates and thank to FAO who has chosen Cambodia as a host of this regional event.

In this special event I would like to share with the participants that the agriculture shares 29.6% of the GDP and provides job opportunity for about 70% of the total population. the vision of the MAFF is to make enough and safety food availability for all people, the poverty will be reduced, and increasing the GDP per capita and sustainable natural resources management and conservation and the sectoral goal is to ensure food security, increase incomes, create employment and improve nutrition status for all people by improving the productivity and diversification and commercialization of agriculture with environmentally sound protection and food safety.

Vegetable crops are the second most important commodity after rice. Vegetables provide an affordable source of nutrition for lower income families. As short duration crops, vegetables are also a source of much needed cash for farmers, especially those with access to irrigation water from rivers, lakes, creeks and open wells. Therefore, assisting farmers to produce high quality vegetables in sufficient quantities to satisfy individual consumption requirements and meet the growing demand for 'clean' vegetables by local fresh markets, supermarkets, restaurants and hotels catering for international visitors is high priority.

The RGC attaches a great importance to IPM farmer training and is committed to introduce IPM as a means to ensure food security on sustainable fashion. MAFF has placed a high priority on IPM Programme and recognizes the Farmer Field School (FFS) approach as an appropriate and effective way for diffusing sound practices and technologies to and for empowering farmers. MAFF officially endorsed Integrated Crop and Pest Management (IPM) as the country's key crop production strategy and established National IPM Programme to facilitate coordination of all IPM activities in Cambodia irrespective of the number and type of donor agencies and crops.

In collaboration with many development partners especially FAO the IPM Programme has trained more than 600 District Trainers on rice, vegetables, mung bean and watermelon; more than 2,000 Farmer Trainers and about 100,000 farmers through season-long FFSs. The IPM training leads to more sustainable and cost-effective production, reduction of ecological disruption and environmental contamination, reduction of public health and toxic residues in food and improvement of livelihood, biodiversity and marketability of produces. This makes a huge contribution to food security promotion, poverty alleviation, and ultimately to the national economic growth which are the priories of the Royal Government policy and strategy.

Along with these successes, however, there are still rooms for improvement especially with regards to capacity building for effectively dealing with major vegetable disease problems, particularly for off -season vegetable production in the tropical lowlands in an economically and environmentally conscious manner.

It is expected that this training workshop will provide an opportunity for resource persons and participants to work together to review disease management principles, discuss and share local experiences, undertake practical activities to further develop understanding of disease physiology, improve disease symptom diagnosis and management and develop training materials and curriculum that can be incorporated into FFS and FFS follow up training activities for farmer education in their respective countries.

Again, on behalf of DAALI, I would like to express profound thanks to the National IPM Programme and FAO for organizing such a useful regional training workshop. Also, thanks to the resource persons and participants who have spared valuable time to attend this workshop.

Finally, I would like to convey to you all the five wishes of the Buddha: longevity, beauty, happiness, healthiness, and prosperity forever. And now I declare the workshop opened.

Annex 5 Summaries of country presentations given in the RVDDEM Training.

5.1 Vietnam

Vegetable cultivation is one of the most important agricultural practices in Vietnam, occupying over one million hectares in both high and lowland areas. While several hundred different crops are grown, tomato, bean, cabbage, pumpkin and cucumber make up a significant proportion of total vegetables produced.

Throughout Vietnam 60% of crops are grown between Spring and Winter, while the Autumn-Summer and Winter-Autumn seasons each account for 20% of total vegetable production.

The use of hybrid varieties, better fertilizer management, improved irrigation and the application of advanced technologies have all resulted in improved yields in recent years. However, pest and disease problems remain limiting factors. The major vegetable diseases in Vietnam are listed in **Table 7.**

Table 7 Major diseases in vegetable crops in Vietnam.

Vegetable crop family	Pathogen
Crucifers	Bacterial soft rot (*Erwinia ceratovora*
	Clubroot
	Alternaria leaf spot (*Alternaria brassicae*)
	Damping off
Solananaceae	TMV tomato mosaic virus
	CMV Cucumber mosaic virus
	TYLCV tomato yellow leaf curl virus
	Late blight (*Phytophthera infestans* (Mont.))
	Bacterial wilt (*Pseudomonas solanacerum* (Smith)) Anthraocnose
	Fusarium wilt (*Fusarium oxysporum* Schl)
	Downy mildew (*Pseudoperonospore cubensis*)
Cucurbits	Fusarium wilt (*Fusarium oxysporum* Schl)
	CMV Cucumber Mosaic Virus
	Powdery mildew (*Erysiphe cucurbitacearum* Zheng)
	Fusarium wilt (*Fusarium oxysporum* Schl)

Future activities that aim to improve vegetable disease management

- Organize training courses for IPM facilitators and trainers

- Undertake refresher courses for IPM trainers
- Implement Participatory Action Research activities on major crops and diseases: clubroot, wilts, late blight, virus and nematode disease
- Apply and utilize advanced technology and cultivation methods such as biofumigation, skim milk and cow urine
- Evaluate the results of vegetable disease management activities
- Organise review workshop to report and discuss the activities and results of vegetable disease management activities.

5.2 Thailand

Vegetable production in Thailand occupies approximately 2.3 million rai (1 rai = 1,600m^2) and is separated into three main geographic regions: North (upland), North Eastern (plateau and upland) and Central (plain). Major crops grown belong to the Solanum, brassica and cucurbit crop families .

The major diseases that limit vegetable production include:

- Damping Off (complex of pathogens)
- Bacterial soft rot (*Erwinia ceratovora)*
- Anthracnose (*Colletrichum orbiculare* (Berk))
- Black spot (*Xanthomonas cempestris)*
- Powdery mildew (*Oidium sp, Erysiphe polygoni)*
- Tomato and Cucumber Mosaic viruses (TMV, CMV)
- Bacterial wilt (*Pseudomonas solanacerum* (Smith))
- Downy mildew (*Pseudoperonospore cubensis)*
- Root knot nematode (*Meloidogyne* sp.*)*

Application of lime, soil solarisation, good drainage, proper plant spacing, application of composts and organic fertilizers, nursery and field sanitation and crop rotation are standard practices in vegetable production in Thailand.

The role of the Thailand Department of Agricultural Extension (DAOE) is to:

- Transfer IPM technology using the FFS approach;
- Provide agronomic advice to farmers;
- Supply farmers with biological alternatives to chemical pesticides;
- Compile pest insect data collected by volunteer farmers.

The future needs for strengthening curricula and training on vegetable disease management in Thailand include:

- Better understanding of the plant pathogens and their biology;
- Better understanding of vegetable disease management;
- Improved facilitation skills of agricultural extension officers.

5.3 The Philippines

Rice, corn, and vegetables are the staple crops grown in The Philippines while banana, pineapple, coconut and mango are produced mainly for export. The province of Nueva Ecija is considered the food basket of Central Luzon and known to be the highest producer of rice - the staple food of the Philippine diet. Apart from rice, Nueva Ecija produces a large amount of vegetables; onions are the second major crop followed by eggplant, tomato, bitter-gourd string beans, okra, green pepper, squash, pechay and green mustard.

Due to the pronounced changes in climatic conditions in the country, vegetable growers face many problems when producing crops. The emergence of new insect pests and disease

problems lower the potential yields thus decreasing farmer income. The most serious plant diseases include:

- fusarium wilt *Fusarium oxysporum* (Schl)
- stem rot *Erwinia ceratovora*
- leaf blight *Ascochyta* sp.
- early blight *Alternaria solani* (Sorauer)
- late blight *Phytophthera infestans* (Mont.)
- downy mildew *Pseudoperonospore cubensis*
- powdery mildew *Oidium sp, Erysiphe polygoni*
- leaf spot *Alternaria brassicae*
- anthracnose *Colletrichum orbiculare* (Berk)
- damping off *Fusarium oxysporum*
- phomopsis *Phomopsis juniperovora* (Hahn)
- bacterial wilt *Pseudomonas solanacerum* (Smith)
- TYLCV Tomato yellow leaf curl virus
- TMV Tomato mosaic virus
- TSWV Tomato spotted wilt virus
- CMV Cucumber mosaic virus
- ZYMV Zucchini yellow mosaic virus
- WSMV Watermelon spotted mosaic virus

Local extension workers and research institutes work together to identify disease management solutions, e.g., alternative biological options such as antagonistic microorganisms.

With much concern toward the health of the environment and humans, the government is enthusiastic to promote alternatives to pesticides, paying particular attention to the development of biological solutions to disease problems. Results from studies are being tested and extended to farmers through farmer field schools and technology demonstrations. Still greater effort needs to come from government and private entities to foster and develop more biologically sound agricultural practices. Collaborative opportunities that improve farming practices and offer greater support to farmers are welcomed.

5.4 Nepal

Nepal is a Himalayan country situated in between two Asian giants, China and India. The topography of Nepal ranges from 52m to 8,848m above sea level and the total area is 147,181km^2. In 2001, the country's total population reached 23.1 million with more than 103 ethnic groups and 93 spoken languages. Hindus and Buddhists make up the majority of the population.

In Nepal, agriculture contributes to 38% of the country's total GDP. Approximately 66% of the population is engaged in -and reliant on- agriculture as the main livelihood option. The country is divided in 3 major agronomic regions, i.e terai (low-lying plains) (70-1,000m), mid-hill (1,000 m -2,000m) and high hill or mountain (>2,000 m).

Agricultural statistics show that vegetable production covers approximately 189,832 hectares of the land area and the total vegetable production is around 2,190,100 metric tons per year. The productivity of vegetable crops is approximately 11.53 metric tons per hectare. The area and productivity of vegetable crops is increasing daily and many farmers of terai (plain area) and mid-hills have started commercial vegetable farming.

The major vegetable crops that are grown in the country are cole (cauliflower, cabbage, broccoli, knoll khol), solanum (tomato, brinjal, sweet pepper, chilli), cucurbit (cucumber, pumpkin, bitter gourd, bottle gourd, sponge gourd, squash), legumes (garden pea, cowpea, French bean), onion, garlic, raddish, carrot, broad leaf mustard, spinach, coriander, lady's finger and chayote.

5.5 Lao PDR

Rice is the primary crop grown by over 80% of the population of Lao PDR. Vegetables are the second highest crop with the total land area reaching an estimated 85,710 hectares during two seasons in 2005. In the dry season, leafy stem vegetables occupied 24,500 hectares, root crops (bulb and tuber) 5,400 hectares while fruit and legume crops occupied 16,285 hectares. In the rainy season, leafy stem vegetables were grown on 20,740 hectares, root crops (bulb and tuber) covered 2,555 hectares while fruit-bearing and legumes occupied 16,230 hectares. Tomato, cabbage, cauliflower, cucumber, Chinese kale are most seriously affected by various diseases. Diseases and management techniques are summarized in **Table 8**.

Table 8 Major diseases effecting vegetables in LAO PDR

Tomato	bacterial wilt *Pseudomonas solanacerum* (Smith) late blight *Phytophthera infestans* (Mont.) black mold *Aspergillus niger* TLCV tomato leaf curl virus
Cabbage	leaf spot *Alternaria sp* soft rot *Erwinia ceratovora* black rot *Xanthomonas cempestris* complex of soil-borne pathogens causing damping off
Chinese kale	downy mildew *Pseudoperonospore cubensis* complex of soil-borne pathogens causing damping off
Legumes	leaf spot *Alternaria sp* anthracnose *Colletrichum orbiculare* (Berk) rust disease *Uromyces appendiculatus* (Pers)
Cucumber	CMV cucumber mosaic virus downy mildew *Pseudoperonospore cubensis*

Future plan to reduce or control damage caused by these diseases:

- Use biological control such as *Trichoderma sp*. for the control of soil-borne pathogens.
- Use organic matter to increase soil microorganism activity that lower population density of pathogens.

5.6 Indonesia

The Experience of FFS Alumni in Facilitating Upland Vegetables, Segoro Gunung Village, Ngargoyoso Subdistrict, Karanganyar Regency, Central Java

Management of upland vegetable pest and diseases mainly relies on either chemical insecticide or fungicide use. When control of these pests relies too heavily on chemical compounds the natural environment for beneficial microorganisms is negatively affected negatively affect as is the quality of the harvest products. The worst effects are the emergence of pest and disease resistance resulting in dramatic population increases and the possibility of the emergence of new pests and diseases which are a greater threat to farmers. This often results in harvested products containing unsafe levels of pesticide residues.

Some of the main vegetable diseases are bacterial wilt on potatoes and clubroot on cabbages. Clubroot disease inhibits cabbage plant growth to such an extent that all yield can be lost. Meanwhile, bacterial wilt reduces the quantity and quality of harvested products. Efforts are underway to control such diseases, for example: to prevent the proliferation of clubroot disease, sterile soil is used during seed production. Bacterial wilt that infects potato plants is controlled by picking the infected tuber seeds and annihilating them or by sanitizing the terrain.

The results of recent work utilising biofumigation to control clubroot in cabbages and bacterial wilt on potatoes has shown that the incorporation of chopped cabbage plant residues into soil can suppress disease and protect plants from clubroot and produce heads weighing up to 2kgs. A similar result was obtained when investigating bacterial wilt on potato plants. However obstacles during the experiments, that need to be considered when making recommendations to farmers, include:

- the limited availability of brassica tissue for biofumigation;
- chopping and incorporating plant material is laborious and time-consuming;
- the distribution and incorporation of brassica tissue must be uniform to achieve good results;
- further demonstration and promotion of biofumigation is required to convince more farmers to adopt the technology.

Further experiments needs to be conducted in Indonesia to determine the best application technology to macerate and incorporate brassica tissue to obtain the highest possible levels of ITC release.

Other practices include the use of cow urine to control pests and diseases. Cow urine is also a useful fertiliser. This ‘biopesticide’ can control some caterpillars as well as thrips (except green thrips). This has become more relevant lately as thrips have been recognized as carriers for viruses. Careful observation is an important component of vegetable disease management therefore it is necessary to highlight this in FFS. The techniques and principles of this disease diagnosis, ecology and management training will be shared with FFS, Alumni FFS, TOT and farmers.

5.7 China

Nanning is the capital city of Guangxi Zhuang Autonomous Region, located in the south of China bordering Vietnam. Within Nanning prefecture are six counties and districts occupying

a total land area of 22,293km^2. The climate is subtropical monsoon with long humid summers and short dry winters favorable for growing 115 different varieties of vegetables on 146,729 hectares. Economic development in China has increased demand for fruits and vegetables and provided an opportunity for farmers to move away from less economically rewarding crops such as rice and corn.

Apart from insect pests, 175 vegetable diseases attack and reduce the yield of vegetable crops by approximately 12,000 tons each year. The main vegetable diseases are summarized in **Table 9.**

IPM was introduced to Nanning in mid 1980's to:

- Improve management of pesticides;
- Provide training to agro-technicians and farmers;
- Introduce new techniques, varieties and biological pesticides.

Since then significant investment has taken place into the use of insect attractants and sex pheromone based traps.

The limitations IPM adoption has faced:

- Lack of understanding of the principles of IPM taught to farmers;
- The difficulty involved with identifying plant diseases and disorders;
- The small and fragmented size of land holdings;
- The excessive and indiscriminative use of dangerous pesticides;
- Limited post-harvest, transportation and marketing skills.

Table 9 Major vegetable diseases in China

Vegetable crop family	Pathogen
Crucifers	TuMV, CMV, TMV
	Bacterial soft rot (*Erwinia ceratovora*)
	Downy mildew (*Pseudoperonospore cubensis*)
	Sclerotiose (*Sclerotinia sclerotiorum*)
	Alternaria leaf spot (*Alternaria brassicae*)
	Black rot (*Xanthomonas campestris*)
Solananaceae	TMV, CMV, PVX, PVY
	Early blight (*Alternaria solani* Sorauer)
	Late blight (*Phytophthera infestans* (Mont.))
	Bacterial wilt (*Pseudomonas solanacerum* (Smith))
	Fusarium wilt (*Fusarium oxysporum* Schl)
Cucurbits	Downy mildew (*Pseudoperonospore cubensis*)
	Fusarium wilt (*Fusarium oxysporum* Schl)
	Phytophthora wilt (*Phytophthora drechsleri* Tucker)
	Powdery mildew (*Erysiphe cucurbitacearum* Zheng)
	Gummy stem blight (*Ascochyta citrullina* Smith)
	WMV, MMV, CMV
	Anthracnose (*Colletrichum orbiculare* Berk.)
Legumes	Fusarium wilt (*Fusarium oxysporum* Schl)
	Legume rust (*Uromyces appendiculatus* Pers)
	Powdery mildew (*Oidium sp, Erysiphe polygoni* DC)

Strategies for improving and strengthening IPM within Nanning Province focus on:

- Providing further learning opportunities for farmers
- Providing further learning opportunities for trainers
- Promoting private sector investment in agriculture

5.8 Bangladesh

Vegetables are one of the main crops in Bangladesh. Many insect pests and diseases cause yield losses each year. Farmers usually apply pesticides to control pests and diseases. Since 1997 the vegetable farmers have been trained in FFS through the Department of Agriculture Extension (DAE) supported by several agencies promoting IPM. As a result the trained farmers are able to reduce pesticide use and increase their yield. But still most farmers can't diagnose vegetable diseases correctly. More attention is needed to strengthen the capacity of the FFS facilitators about vegetable disease diagnosis, ecology and management.

The total area of Bangladesh is 147,575km2 of which 66.6% is available for cultivation. Rice alone covers about 79% of the total cropped area. The total land area dedicated to vegetable is about 679,000ha. About 100 vegetable varieties are grown in Bangladesh with nine major crops (potato, brinjal, tomato, bean, cabbage, cauliflower, gourd, okra and radish). The major constraints to increasing vegetable production are insect pests and diseases. Estimated annual vegetable crop losses due to disease ranges from 10-15%. Most of the vegetable growers in Bangladesh rely on chemicals to manage the diseases.

So far 94 diseases have been recorded from 9 major vegetable crops in Bangladesh. Of these diseases, 32 are considered major threats to production. The most common vegetable diseases include:

- Damping Off (*Fusarium oxysporum* (Schl))
- Late blight *Phytophthera infestans* (Mont.)
- Early blight *Alternaria solani* (Sorauer)

- Leaf spot *Colletrichum orbiculare* (Berk)
- Root and fruit rot *Phytophthora drechsleri* (Tucker)
- Anthracnose (*Colletrichum orbiculare* (Berk))
- TMV tomato mosaic virus
- TYLCV tomato yellow leaf curl virus
- YVCV yellow vein clearing virus
- Root knot nematode (*Meloidogyne* sp.*)*

Since the Vegetable IPM programme was developed, 4,105 vegetable FFS have been conducted, in initially with FAO support and later with DANIDA IPM support. The following management strategies and techniques have been utilised for vegetable disease management by IPM trained persons and farmers in Bangladesh:

- Use of some tolerant / resistant varieties of 6 major vegetable crops for 17 diseases
- Use of soil amendments of seed bed disinfection (poultry refuse, mustard oil cake etc)
- Soil solarisation
- Seed treatment by garlic extract
- Use of balanced fertilizers
- Weeding and field sanitation
- Proper water management
- Management of crop residues
- Grafting with wild solanum crops
- Use of microorganisms (*Trichoderma hazaranum* fungus at laboratory studies)
- Maintaining proper spacing and planting time
- Control insect vectors
- Use of agrochemicals

Recent events in Bangladesh:

- Vegetable farming is increasing day by day and some vegetables have been welcomed into foreign markets;
- Efforts have been made to produce chemical-free vegetables in the homestead area;
- Attempts have been made to develop more IPM trainers to facilitate FFS activities on rice and vegetables;
- Female farmers are encouraged to join –mostly separate- IPM groups and will be trained in FFS on vegetable production and pest management, particularly for homestead production. More vegetable FFS will be conducted in all the districts;
- Farmer trainers are being developed on vegetable IPM;
- IPM trained farmer associations have been formed to strengthen local agricultural advisory services;
- Conducted studies and exercises to consider new vegetable diseases management technologies.

5.9 **Cambodia**

The Cambodian National IPM Programme was initiated in 1993 by MAFF after a National Workshop on "Environment and IPM". The overall goal is to improve food security and safety through the promotion of Integrated Pest and Crop Management skills at the farm level. IPM enables farmers to grow healthy crops with high yields leading to production sustainability and socio-economic effectiveness, while safeguarding human health and protecting the natural environment.

Cambodia is a country that is largely dependant on agriculture. Vegetable crops are the second most important commodity after rice. Cambodian farmers grow all kinds of vegetables (pod, leafy, fruit and root crops) in proximity to water sources, mainly along the rivers, creeks, lakes and open wells for easy access to irrigation. Major vegetable crops that are

normally grown in the dry season (Oct-Mar) are cabbage, Chinese cabbage, cauliflower, Chinese kale, onion, leaf lettuce and tomato. Important vegetable crops grown during the wet season (May-Sept) include cucumber, squash, shallot, gourds, bean and chilies. Major producing provinces are Kandal, Kampot, Siem Reap, Takeo, Kampong Cham and Battambang.

In total 172,399 tones (35,762 ha) of vegetables were harvested in 2006 (MAFF). In the wet season 93,257 tones of vegetable were produced (20,481 ha), while in the dry season 79,042 tons of vegetables were produced (15,281ha). The main diseases faced by vegetable growers in Cambodia are listed in **Table 10**

Table 10 Vegetable diseases in Cambodia

Vegetable crop family	**Pathogen**
Crucifers	Bacterial soft rot *Erwinia carotovora* and *Pseudomonas marginalis pv. marginalis*
	Black rot *Xanthomonas cempestris*
	Damping off *Pythium* and *Rhizoctonia*
	Bacterial soft rot (*Erwinia ceratovora*)
	Alternaria leaf spot (*Alternaria brassicae*)
	Black rot (*Xanthomonas campestris*)
Solananaceae	Late blight (*Phytophthera infestans* (Mont.))
	Early blight (*Alternaria solani* Sorauer)
	TYLCV tomato yellow leaf curl virus
	Bacterial wilt (*Pseudomonas solanacerum* (Smith))
	Fusarium wilt (*Fusarium oxysporum* Schl)
	Downy mildew (*Pseudoperonospore cubensis*)
Cucurbits	Downy mildew (*Pseudoperonospore cubensis*)
	Powdery mildew (*Erysiphe cucurbitacearum* Zheng)
	CMV cucumber mosaic virus
	Anthracnose (*Colletrichum orbiculare* Berk.)
	Fusarium wilt (*Fusarium oxysporum* Schl)
Legumes	Powdery mildew (*Oidium sp, Erysiphe polygoni* DC)
	Legume rust (*Uromyces appendiculatus* Pers)
	Damping off (species complex)

The focus of disease management within the Cambodian IPM programme include:
Educating farmers in FFS and post-FFS

- Train IPM trainers on vegetable disease management
- Conduct field studies to educate farmers with ways to manage disease and grow healthy crops in FFS and post-FFS

General diseases management practices promoted within field schools include
Fungus pathogens:

- Rotate crops
- Ensure seed and soil are disease free
- Producing healthy seedling/crop
- Using lime to control soil born diseases
- Reducing moisture (proper drainage, irrigation and spacing)
- Reducing Nitrogen
- Making field sanitation
- Removing disease plants or some parts that infected (infected leaves)
- Using fungicide

Bacterial pathogens

- Ensuring seed and soil are disease free
- Use resistant variety
- Rotate crops
- Practice field sanitation

Viral pathogens

- Using resistant variety
- Rotate crops
- Manage insect vectors
- Protected seedling cultivation
- Removing infected plants and field sanitation

Annex 6. Acronyms and *Genus and species names*

Pathogen	**Accronym/*Genus species***
TuMV	Turnip mosaic virus
CMV	Cucumber mosaic virus
TMV	Tomato mosaic virus
PVX	Potato virus Y
PVY	Potato virus X
WMV	Watermelon mosaic virus
MMV	Maize mosaic virus
TSWV	Tomato spotted wilt virus
TYLCV	Tomato yellow leaf curl virus
ZYMV	Zucchini yellow mosaic virus
WSMV	Watermelon spotted mosaic virus
Bacterial soft rot	*Erwinia ceratovora*
Downy mildew	*Pseudoperonospore cubensis*
Sclerotiose	*Sclerotinia sclerotiorum*
Alternaria leaf spot	*Alternaria brassicae*
Black rot	*Xanthomonas cempestris*
Early blight	*Alternaria solani* (Sorauer)
Late blight	*Phytophthera infestans* (Mont.)
Bacterial wilt	*Pseudomonas solanacerum* (Smith)
Fusarium wilt	*Fusarium oxysporum* (Schl)
Downy mildew	*Pseudoperonospore cubensis*
Fusarium wilt	*Fusarium oxysporum* (Schl)
Phytophthora wilt	*Phytophthora drechsleri* (Tucker)
Powdery mildew	*Erysiphe cucurbitacearum* (Zheng)
Gummy stem blight	*Ascochyta citrullina* (Smith)
Anthracnose	*Colletrichum orbiculare* (Berk)
Fusarium wilt	*Fusarium oxysporum* (Schl)
Legume rust	*Uromyces appendiculatus* (Pers)
Powdery mildew	*Oidium sp, Erysiphe polygoni*
Clubroot	*Plasmodiophora brassicae*
Root knot nematode	*Meloidogyne* sp.

Annex 7. List of handouts and other useful information sources on disease management in the lowland tropics

7.1 Reference material and handouts

Bennett. W.F. 1996 Nutrient Deficiencies & Toxicities in crop plants
The American Phytopathological Society Press. Minnesota USA.

Black L. L., 2007. Vegetable Diseases: A Practical Guide. For use and distribution in the Regional Vegetable Disease Diagnosis, Ecology and Management Training, Phnom Penh Cambodia 19-28 September 2007.

CABI Bioscience/FAO. 2000. Vegetable Integrated Pest Management Exercise Manual. CABI Bioscience and The FAO Intercountry Programme for the Development and Application of Integrated Pest Management in Vegetable Growing in South and South-East Asia.
Clark. C.A., Moyer. J.W. 1998. Compendium of Sweet Potato Diseases. The American Phytopathological Society Press. Minnesota USA.

Curwen. D., Ferro. D.N., Loria. R., Secor. G.A. Ed: Crowe. R.C. 1993. Potato Health Management. The American Phytopathological Society Press. Minnesota USA.

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Compendium of Lettuce Diseases. The American Phytopathological Society Press. Minnesota USA.

Maas. J.L., 1998 Compendium of Strawberry Diseases 2nd Edition.
The American Phytopathological Society Press. Minnesota USA.

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McDougall. S., Napier. T., Valenzisis. J., Duff. J., Geitz. G., Franklin. T. 2002 Integrated Pest management in Lettuce: Information Guide. NSW Department of Primary Industries Horticulture Research and Development Corporation.

Ploetz. R.C., Zentmyer. G.A., Nishijima. W.T., Rohrbach. K.G., Ohr. H.D. 1998. Compendium of Tropical Fruit Diseases. The American Phytopathological Society Press. Minnesota USA.

Pyone P. K., 2007. How to isolate Plant-Pathogenic Nematodes.
Plant Pathology Section, Plant Protection Division Bayintnaung Rd., West Gogone, Insein, Myanmar. Email: ppmas.moai@mptmail.net.mm and kyautpyone@gmail.com

Schwartz. H.F., Mohan. S.K. 1999. Compendium of Onion and Garlic Diseases. The American Phytopathological Society Press. Minnesota USA.

Resource information was also included on a number of CD's, these electronic resources were distributed to participants along with country presentations and the RVDDEM training report.

- Diseases of Legumes
- Diseases of Small Fruits
- Nutrient Deficiencies and Toxicities of Plants
- Crop Protection Compendium
- Sweet Potato Diag Notes

- Diseases of Vegetables
- Field Guide to Pests, Diseases and Disorders of Vegetable Brassicas

7.2 Internet information sources:

CAB International
http://www.cabi.org/

FAO
http://www.fao.org/

FAO Community Integrated Pest Management
http://www.communityipm.org/index.htm

Ecological Agriculture
http://peopleinaction.com/archive/agriculture.html

Annex 8 Closing Remarks

8.1 Daily Summary Report of RVDDEM Training Mr Chouchey Thyrith

- His Excellency
- Regional FAO IPM Programme Team Leader
- FAO Representative in Cambodia
- Resource Persons
- Participants

On this special occasion, on behalf of the training workshop management team, I have a great pleasure give you the summary of the major activities and what have transpired during the 8 days of the regional training workshop on Disease Identification, Ecology and Management.

The training workshop was participated by 29 participants from 9 countries: 2 from Bangladesh, 3 from China, 12 from Cambodia, 1 from Indonesia, 2 from Laos, 2 from Nepal, 1 from the Philippines, 3 from Thailand and 3 from Vietnam.

On the first day of the session, each representative presented the country's situation on vegetable production, crop diseases encountered and the numerous management options. We found out that we are encountering common problems and practices and those new to us were shared with others. The lecture proper started with the presentation on the Principle of disease ecology and management, by Dr. Marilyn Patricio, a pathologist from the Philippines. She explained what is disease, the factors that affect its development and the various kinds of microorganisms that cause plant diseases. This introduction opens our minds in the world of plant pathology.

The second day was a very exciting experience. The participants visited a field for observation and disease collection. Group 1 and 2 visited Yard Long Bean Field in Svav Kanleng village, Bonthey Dek commune and Kien Svay district, and group 3 and 4 visited Allium crop in Peam Sala village Saang Phnom commune, Saang district Kandal province. Every group performed the task as instructed: get the general information about the field, observed the crop on diseases occurrence and asked the farmers about their control practices. The whole afternoon was devoted to discussion and exercises on symptom identification.

The third day was also devoted to field observation and disease collection but on different crops. This time the participants did a deeper observation and analysis of the factors that affect disease development on the field. Classroom discussion was also more detailed and participants improved their capability on symptom identification.

The fourth day was devoted to performing exercises related to disease transmission and development. In this we set up simple experiments for disease transmission and development for observation on the following days. We did observation of different microorganisms through microscope, practiced the inoculation process and developed session guides which made this half day session complete. Participants were also given assignment to prepare their country strategy plan, what will they do in returning back to their country of assignment. During their free time in the afternoon, participants were given the chance to go around the city, visit the market and bought souvenir items to be taken home.

The fifth day was focused on Viral diseases and Nematodes. Dr. Prabhat Kumar delivered his lecture on vegetable virus diseases and vectors giveing emphasis to White fly for tomato yellow leaf curl virus which is the common problem in the region. Participants learned various viral diseases and their management and control methods. Simple exercise was also set up for the viral infection of a vector to a healthy plant. The whole afternoon was devoted to discussion about Nematodes facilitated by Dr. Pyone Pyone Kyi from Myanmar. She discussed the identification of Plant-Parasitic Nematodes, above and below ground symptoms and signs of plant diseases caused by plant-parasitic nematodes, how to isolate Plant-Parasitic Nematodes and how to do sampling from field. She also gave some pointers on using management. As an experience, participants were able to see nematodes through microscopes.

On the sixth day, participants went on a long trip to visit post-FFS activities in Sre Spey village, Kong Chey commune, Orang Ov district and Kampong Cham province. Activities conducted were: Field observation and discussion on the set up experiments on varietal trial and its effect on plant diseases, observation on the experiments on the use of different kinds of soil sterilization and performance of the seedlings. In the afternoon, the participants performed field exercise on bio-fumigation. They performed the activities from choppings of brassica up to incorporation, watering the field and putting on plastic covers. This exercise was very practical on the part of the participants who had not yet performed this exercise. Another set up was made through the use of common weeds like siam weed. The process was the same as for brassica. Even though tiring this day's activities was very useful to the participants.

On the seventh day, Dr. Lowell L. Black presented topics on diseases of tomato, pepper and chilli, cucumber, crucifer and alliums crop. He discussed in detailed the characteristics of each pathogen, the factors causing diseases, symptoms and signs development and control measure in which the participants' awareness and understanding on the different kinds of diseases and control measures increased. The participants were also given spare time to work on their country strategy plan for the next day's presentation.

Every group observed the result of their experiments (disease inoculation) and presented to the whole group for critiquing and discussion. Then, Dr. Prabat Kumar reviewed the Tomato Yellow Leaf Curl Virus to ensure greater understanding.

On the last day, participants were given time for a Panel Discussion: All participants were given a chance to ask questions about unclear issues to the panel composed of Mr. Jan Willem Ketelaar, Dr. Lowell Black, Dr. Marilyn Patricio, Ms. Valeriana Justo and Dr Probhat Kumar. Participants were enlightened on some issues and given additional information on the topics discussed during the past days. We were also given an opportunity to understand the collaboration projects between the government and private sector on the issue of disease management.

Before the end of the session, participants from every country presented their country strategy plan that will be implemented in their own country after the training workshop. Comments and suggestions were provided by the panel.

His Excellency, Ladies and Gentlemen, this training workshop does not only provide us new concept and methods of vegetable disease diagnosis, ecology and management, but also learned different considerations that should be looked up to in the management of the disease. Disease management is very complex requiring expertise and patience. If not given the appropriate attention this will create a huge problem that would affect not only the living condition of the farmer but the country's economy as a whole.

The participants are very lucky to have been given the opportunity to attend such a training workshop as this. You did not only provide us the technical know how but we also gained confidence in dealing with the farmer's major problem on vegetable production which is the diseases. As the participants go back to their own country they will be bringing home all the lessons learned and experiences and will share these to their clientele.

Again, on behalf of training management team, I would like to express my sincere thanks to His Excellency, Regional FAO Team Leader, FAO Representative in Cambodia who have spared valuable time to attend the closing ceremony. I would also like to thank all the participants who were working very hard doing exercises and sharing experiences from every country. Special thanks is conveyed to the resource persons who provided wonderful and comprehensive concept, method of managing vegetable diseases, unselfishly shared their experiences which made the participant competent in attending the needs of farmers in their own country. Finally, I would like to wish you all the best with great success in your work.

Annex 8.2 Closing Remarks by the FAO Representative, Kimoko Uno

Respected Director General of MAFF, Mr. Koum Sarom, facilitators, resource persons and participants at this FAO Regional Training,

It is with pleasure that I address you all –on behalf of FAO- during this closing session of the FAO Regional Training on Disease Identification, Ecology and Management here in Phnom Penh!

Pesticide abuse and overuse is still rampant in the Asia region. Farmers are overusing pesticides in desperate attempts to control pest and disease problems, often to no avail! Intensive use of extremely and highly hazardous chemicals by small-holder farmers is causing high incidence of farmer poisoning, causing serious disruptions in eco-system functioning and damaging the environment. Given the renewed attention and current prominent driving forces for pesticide risk reduction related to food safety, international trade facilitation and enduring environmental and health concerns, the need for strong Integrated Pest Management (IPM) and Good Agricultural Practices (GAP) farmer training Programmes is greater than ever!

FAO has been implementing IPM farmer training Programmes in Cambodia and elsewhere in the Asia Region for the last 2 decades. As recently confirmed by the Independent External Evaluation of FAO –and the Cambodia Country Evaluation in particular-, the Farmer Field School has been a successful training approach used for training farmers in IPM and other subject matters, including food security, integrated farming systems and health & nutrition. As a result, farmers have been able to significantly reduce the use of pesticides, thereby increasing net returns, reducing pesticide risks to applicators, eliminating yield losses caused due to secondary pest outbreaks, improving the health of ecosystems, reducing negative impact of intensive agriculture on the environment and improving food safety due to reduced levels of residues on crop produce. IPM is GOOD for farmers and consumers alike and thus deserves full government support in terms of policy reform and resources to locally sustain such farmer education Programmes!

Obviously, correct disease diagnosis and understanding of –and access to- ecology-based effective disease prevention and management options is crucial for reducing pesticide use in vegetable production in Cambodia and elsewhere in the Asia region. This Training brings together a diverse group of IPM trainers from 9 countries across Asia with a key interest and experience in vegetable disease matters. During this 9-day intensive training you have increased your knowledge and skills on vegetable disease identification, ecology and management. I understand you all formulated concrete country strategy action plans to ensure that lessons learned and experience gained at this course with be put to good use to strengthen ongoing IPM training Programmes in your own countries. I wish you all good luck with the important IPM farmer training work!

Finally, I would like to thank the Cambodian government –and the National IPM Programme in particular- for co-hosting this regional training here in Phnom Penh! Also sincere thanks are due to all the resource persons, facilitators and support staff who have participated, facilitated and helped organize this successful training course. I wish you all a pleasant farewell cruise and dinner on the Mekong this evening and a safe travel back home to your countries from tomorrow onwards!

Thank You!