



Food and Agriculture Organization  
of the United Nations

# **FIELD GUIDE EXERCISES FOR**

# **IPM IN VEGETABLES (PART I)**

**Vietnam IPM National Programme**

**Plant Protection Department, MARD  
FAO Hanoi-IPM**

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# Introduction

The Field Guide Exercises for IPM in Vegetables was developed through the efforts of the trainers of the Vietnam National Program, members of the National IPM Group and the FAO staff in Hanoi with contributions from the FAO Regional Programme. Some of the exercises were adapted from the Indonesian Field Guide for Rice IPM and the Palawija Exercises. Some were based on activities done in the vegetable project of the Philippine National Program.

The latest version includes exercises that have been revised or additional exercises to address pesticide-related training needs *in a constructive context*, for example:

- health risks of pesticides adopted or adapted from Helen Murphy's Guide for Farmer-to-farmer IPM Health Studies, including WHO hazard levels and chemical families of pesticides; acute health effects; number of pesticides per tank
- experiments on the development of resistance to pesticides
- experiments comparing pesticide impact on pests and natural enemies
- field demonstration of applicator exposure to pesticides
- study of the comparative performance of chemical insecticides and microbial insecticides (Bt, NPV)

The recent impact evaluation of farmer vegetable training showed increased fungicide use by farmers. This has led to the design of new exercises on diseases based on field studies implemented by farmer groups involved in Participatory Action Research (PAR) on disease management and activities introduced in the last vegetable TOT course by Dr. Janny Vos of CABI.

All of the key, crop-specific aspects of proper and effective pesticide use are covered *in passing* as a low profile aspect of TOT/FFS exercises carried out with an emphatic and consistent focus on PESTICIDE RISK REDUCTION. Reducing pesticide dependence (by employing alternative pest management methods) and reducing pesticide use are two important aspects of pesticide risk reduction; choosing pesticides that are least toxic to people and other nontarget species is another.

The contents of the Field Guide are intended for use of trainers in the implementation of a Season-long Training of Trainers in Vegetables particularly on cabbages, tomatoes and French beans. Most exercises, however, can be used in Farmers' Field Schools. They can also be adapted for use in other vegetable crops. The Guide consists of two parts:

**Part I: General Field Guide Exercises for Vegetables**

**Part II: Crop Specific Field Guide Exercises: Cabbage or Tomato or French Beans**

The General Guide contains exercises along the following areas:

- **Research Methods**
- **Economic Threshold Levels**
- **Ecosystem**
- **Insect Zoos**
- ***Bacillus thuringiensis* (Bt)**
- **Nuclear Polyhedrosis Virus (NPV)**
- **Pesticides**
- **Diseases**
- **Weather**
- **Soils and Nutrients**

The Crop Specific Field Guide contains exercises along the following areas:

- **Field Studies**
- **Ecosystem Analysis Questions**

- **Plant Development**

The design of the field guide has been modified considering the expansion of IPM to other vegetable crops. Therefore, sections which apply to all crops have been put together.

The guide demonstrates the capability of trainers to develop local materials. It is hoped that this output will encourage them to further experiment in the field, write up their experiences and exchange learning with farmers as well as colleagues in the field of IPM.

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# Research Methods





# INTRODUCTION TO RESEARCH METHODS

## *Why research methods?*

Why should we use field studies to understand IPM in the field? And why should we learn more about Research Methodologies if we are not researchers?

First, it is clear that for us who work in the field, we must use the guide to look at problems in the field. We identify insects and diseases in the field by the way they move, fly, smell and develop over time. This is why slides, close up photos and other static materials are not used. Field identifications are different from identifications made by taxonomists that use dead insects. Field studies get us in the field where we can learn and help others learn in a realistic way.

Second is the question about research methods. Every field is slightly different and every farmer/extension worker must adapt to local conditions. This is especially true for varieties, management techniques and pest components. Simple proven methods of testing a new variety or improving fertilizer management use research methods. The goal of learning about these methods is to assist in understanding how to adapt global recommendations to local situations in a reliable way. As an IPM trainer, having these methods in your skill set will make you a valuable assistant to farmer groups interested in improving local methods.

## *How do you do research?*

Actually research is very simple, especially compared to extension work. Researchers set up studies and record the results, good or poor. Extension workers and farmers, however, must give good answers because they are responsible for someone's food. For research we should follow some rules for setting up studies (Research methods part 1): Variability in the field and layout; sampling and recording data (Research methods part 2): Sampling and Data recording; and analyzing data.

Dealing with variability in the field is the key to useful results. The way a study is set up will determine whether the results will reflect the actual questions being answered. Randomized designs and sufficient repetitions of treatments can reduce underlying variation in the environment (e.g. field moisture or soil type). Field layout is very important and very basic to good studies.

Sampling and data recording are essential aspects of research. Sampling methods must be developed to reflect the characteristics of the organisms or parameters being sampled. Sample unit and sample size should be defined before sampling begins to assure precision and accuracy. The way data are recorded will make analysis easy or difficult. The key point is to set up data recording at the beginning of the season to reflect the type of data analysis at the end of the season.

Data analysis includes descriptive statistics (mean, standard deviation and variation) and graphing methods (bar charts, x-y graphs and frequency distribution graphs). Next is the process of determining if there are significant differences between treatments. There are several tests (t-test, And Wilcoxon/Mann-Whitney non-parametric) which will assist in determining if differences in treatment means indicate differences in treatments. An example of the last confusing statement is this: a group of male adults from Hanoi have a mean weight of 62.4 kg, and a group a male adults from Danang have a mean weight of 65.8 kg. Does this difference in average weight between the groups indicate that male adults in Hanoi weigh less than male adults in Danang? Probably not, because each group also has some variability.

In this field guide, we will introduce the simplified statistics method (from the Indonesia National Programme) for data analysis especially for farmers. Simplified statistics looks at averages, consistency, and overlaps of values to analyze if there are significant differences between treatments.

## **PART I: VARIABILITY IN THE FIELD AND LAYOUT**

### ***Introduction***

The main problem we must deal with in research is how to reduce variability in the field. Every field is different from adjacent fields and even fields are different from one side to the other. Water moisture is a good example. One field may be very moist while adjacent fields are dry. If we are doing research on yield due to variety in these fields, the wet areas will have a different yield from the dry areas because of the water and not only due to differences in variety. For rice, the wetter area will probably have a high yield.

For cabbage the wettest place will probably have low yields because of disease. No conclusion about the study can be made directly because of the underlying variability. At the end of the study, no useful statement can be made about the differences in variety if we do not try to control the variability. There are many ways to control variability by using the proper layout and by trying to maintain identical environmental situations (impossible, but as close to identical as possible).

### **Controlling variability by layout**

Randomization and Repetition are important concepts. Randomization assures that one treatment is not placed in a special position. Using the above example, each variety would have equal chance to be placed in a moist or dry part of the field. Randomization can be done many ways. The easiest is to put numbers in a hat and pull out the numbers.

Repetition on the other hand means that each treatment is tried several times. The differences due to variability are reduced by averaging the treatment over several sites. In the above example, each variety would be grown in several places so that sometimes the variety is in a moist place and sometimes in a dry spot. The average of each variety will provide better indication of each variety's relative yield characteristics. If the results look like there are major differences due to moisture, then in another study, perhaps varieties could be tested with several repetitions in moist places, and several repetitions in dry places. How you randomize and repeat treatment is partially determined by the question being asked.

Layout of studies refers to how many times a treatment is going to be tested and where the repetitions are going to be placed on the land available. The size of the land often determines these numbers. On research stations, usually four to ten repetitions of each treatment are made. The size of each repetition (plot size) should be determined by the question being asked. Differences in varieties can be tested in relatively small plots but differences in management need a much bigger area in order to reduce the influences of adjacent plots (consider spray and no-spray field with natural enemy sampling!). In our studies, there are usually three repetitions per treatment. More repetitions would be desirable if we had more land and more time.

In this exercise, we will begin with laying out the studies for this season based on our curriculum and land available. This exercise will concentrate on Layout.

### **Objectives:**

- Explain how different factors contribute to variability in fields
- Layout field studies for the coming season considering soil moisture depth and soil type

### **Materials:**

Paper, pencil, ruler (30 cm), ruler (50 cm)  
Newspaper  
Strong, clear plastic bags

**Method:**

(Note: begin the soil type activity first, then continue with the soil moisture depth activity.)

**a. Field Variability: Soil type**

1. Go to the study area. Collect soil from five different sites and place them in strong clear plastic bags. (It is preferable to use two plastic bags, i.e., put one bag inside the other.) Place the label between the two bags so that it does not get wet and at the same time each of the samples are identified. Use pencil or waterproof marker to write on the label.
2. Add enough water to cover the soil samples. Next mix and shake the soil in water in the plastic bag. Place the bags somewhere to let the soil settle. Do not disturb the bags for at least 30 minutes.
3. When the soil has settled and the water above the soil is clear, measure the different layers in the soil:

Component:

- |                        |          |      |
|------------------------|----------|------|
| a. bottom layer (sand) | ..... cm | ...% |
| b. middle layer (loam) | ..... cm | ...% |
| c. top layer (clay)    | ..... cm | ...% |
| Total height           | ..... cm |      |

(note the smallest particles are closest to the top)

% component = 100 x component height (cm)/total height (cm)

4. Record the data and compare sites. Can you relate the differences to any aspect of the site topography? Is soil moisture related to the soil type? How could you test these questions further?

**b. Field Variability: Soil moisture depth**

1. This activity is to measure soil moisture over a large area to be used for studies.
2. Go to the field area. Make a rough map of the area if you do not already have a map. Choose 25 places in the field over the entire area and mark on the map.
3. To measure soil moisture, we will use the paper absorption method. Cut soil at 90° angle with surface. Place newspaper against soil so that there is good contact. Remove newspaper after 30 seconds. Measure the depth where the paper is dark from being moist. Record the data for each of 25 sites.
4. Describe the variability of soil moisture depth over the entire area. Try to relate the differences to the slope, cropping pattern, irrigation system, etc. Are there major differences in the soil moisture depth? How will these differences influence studies on the site? How can you layout one study so that most of the study is done on similar soil moisture depth or reduces the influence of variation?

**c. Field Layout**

1. Use your data to specify areas of the field that seem to have similar characteristics. Note the size of the area needed for your studies.
2. Now over the area, measure the size needed to give equal size plots for each repetition. Remember that the total number of plots needed is equal to the number of treatment multiplied by the number of repetitions. The plots do not have to have the same shape, but it is better to have a similar shape. Add a 30cm row between plots. Make a map of the area.
3. After the plots have been drawn or laid out in the field, then it is time to assign treatments to each plot. There are many ways of doing this. The best is to use a random assignments do the following:
  - a. On small pieces of paper write numbers from one to the number of treatments.
  - b. Place the numbers upside down so that the numbers can not be seen.
  - c. Choose a number for the first plot and write the number on the layout plan.

- d. Return the number to the other numbers and continue choosing numbers. Repeat for each treatment number only the number of repetitions. For example for a study with four repetitions, return the number if it has not been chosen four times.
4. Layout the field now using the randomized treatments for each study. Place signs indicating the numbers of repetitions and treatments.
5. Why is it important to randomize treatments? Why does each treatment have more than one repetition? Do the numbers give a good randomization of the treatments? Why are maps and signs important? How would you do this with a study that has five treatments and ten repetitions? Why are more repetitions better?

## PART II. SAMPLING AND DATA RECORDING

### Why Sampling?

Sampling is an important part of doing studies and an important part of doing IPM. But there are points that are important to consider for making sampling plans. In an IPM programme, the goal of sampling is to decide if the field population densities of pest insects and their natural enemies is such that some control is necessary. Usually this means that the sampler is trying to decide if the pest is above the action threshold, and if it is above, then whether the natural enemy density is sufficient to control the population.

The second type of sampling is for studies. The actual population level is important to know so that the results of the study can be explained in terms of as many parameters as possible. In studies, it is important to know the development of populations during the season and to have an idea what the effect of these populations have on the study. Also, during this training, we are trying to understand the population dynamics of components of the agroecosystem.

### Recording data

Recording data can be done in many ways. The most important aspect of data recording is that it is done in the same way throughout the season and that the data are clear for later analysis. Data statistics will be computed from the original field data so there should be space on the form for both means and standard deviations. The date, treatment, repetition, and other information should also be placed on each form.

### Objectives:

- Define "population density"
- Make a form for data recording

### Materials (per group of 5):

100 stones (or seeds), crayon, big paper, small sheets of paper, rulers, pencils and pens

### Method:

#### I. What is the meaning of "population density"?

1. Each person in the group first writes down on a piece of paper their own definition of population density. Save this for after the activity.
2. Now, on the large piece of paper, draw a grid (5cm x 5cm) over the entire sheet.
3. Take the stones and spread the stones over the sheet.
4. Fill in attached form by counting the number of stones in 20 randomly selected boxes:

#### Number of stones

	box = 5x5 cm	box = 10x10 cm	box = 15x15 cm
Box 1			
Box 2			
Box 3			
Box 4			
Box 5			
Box 6			
Box 7			
Box 8			
Box 9			

Box 10			
Box 11			
Box 12			
Box 13			
Box 14			
Box 15			
Box 16			
Box 17			
Box 18			
Box 19			
Box 20			
Mean no. stones			
Standard deviation			

- Now convert the number of stones per box to number of stones per square meter: (average number of stones/box size) X 10,000 = number of stones/m<sup>2</sup>. Example: (3 stones/25cm<sup>2</sup>) X 10,000 = 1200 stones/m<sup>2</sup>.
- Measure the total area of the grid. Now convert this number of 100 stones for the actual area to number of stones for 1 square meter. Example: total size of the sheet is 50 X 100 cm<sup>2</sup> = 5000 cm<sup>2</sup>; (100 stones/5000 cm<sup>2</sup>) X 10,000 = 200 stones/m<sup>2</sup>.
- Compare the actual density and the sampled densities. Which of the box size sampling have the best approximation of the actual population density? Why is it important to measure density? Why is it important to be able to convert all measures into numbers/m<sup>2</sup>? Why doesn't percentage make any sense for measuring population density?

## II. Densities and thresholds

Actual density and sampled density is important and useful to know for studies but farmers only need to know if the population density is above or below a certain density. Let's make some examples.

- Assume that the economic threshold level is 50 stones per square meter.
- Now fill out the form below. Spread different numbers of stones on the floor for several samples. Count 10 random boxes each time to make a decision.

Use 10 stones  
 Total stones in 10 random boxes:  
 Average number of stones/m<sup>2</sup>:  
 Above or below ETL:

Use 25 stones  
 Total stones in 10 random boxes:  
 Average number of stones/m<sup>2</sup>:  
 Above or below ETL:

Use 50 stones  
 Total stones in 10 random boxes:  
 Average number of stones/m<sup>2</sup>:  
 Above or below ETL:

Use 75 stones  
 Total stones in 10 random boxes:  
 Average number of stones/m<sup>2</sup>:  
 Above or below ETL:

## *Research Methods*



Use 100 stones

Total stones in 10 random boxes:

Average number of stones/m<sup>2</sup>:

Above or below ETL:

3. When the actual density of stones is above the economic threshold does the sampling give the same result? If you didn't make an exact count could you estimate if the density is above or below the economic threshold? Is it important for farmers to know the density exactly?

**III. Making forms**

It is important to make forms that reflect the questions being asked for each study. We are especially interested in insect and natural enemy population densities in many studies. Development of the plant, disease and other aspects are important in other studies.

1. To make a form, first list the data to be collected. Include information about the study, dates, and names of the sampling team.
2. Now decide which information is to be collected once during the season and which is collected weekly.
3. For weekly collected data, ten random plants per collection should be selected, so at least ten columns should be made. Two more columns are made for average and standard deviation (SD). Example:

Study:  
 Sampling date:  
 Sampling team:  
 Remarks: (ex. weather, etc.)

	samp. unit 1	samp. unit 2	samp. unit 3...		samp. unit 10	average	SD
Plant height							
# leaves							
<i>Plutella</i> larvae							
Spiders							
<i>Cotesia</i>							
leafspot							

Indicate what unit you use, example plant height in cm, insects in numbers per m<sup>2</sup>, etc.

4. Prepare forms for summarizing the data for the season. The summary should include the average and standard deviation. Example:

Study:  
 Summary of seasonal data  
 Sampling team:  
 Remarks: (ex. table on pesticide use, weather conditions)

	week 1		week 2		week 3		week 4...						
	av.	SD	av.	SD	av.	SD	av.	SD					
Plant height													
# leaves													
<i>Plutella</i> larvae													
Spiders													
<i>Cotesia</i>													

Leafspot														
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Indicate what unit you use, example plant height in cm, insects in numbers per m<sup>2</sup>, etc.

5. Prepare enough forms for the season (the trainers will assist in giving the forms to people who will help type and print and copy them). Do not change forms during the season if possible.
6. Use a dark pencil or black pen to record data so the forms can be photocopied.

### **PART III. DESIGNING STUDIES FOR FFS<sup>♥</sup>**

Field conditions can be very variable and unpredictable, owing mainly to erratic water availability, and the erratic occurrence of different pests. Therefore, it is impractical to have a fixed programme with exercises to be conducted in pre-set FFS sessions (for example study 1 to be conducted in session 1, study 2 in session 2, etc.). Much better is to remain flexible and respond to current field conditions. Only then will we really be able to help farmers with their direct problems.

So far, we have conducted a number of studies as part of the training programme. These studies can be classified in the following categories:

1. Identification / Lifecycles
2. Agroecosystem analysis
3. Influence of natural enemies on pests
4. Plant physiology
5. Risk of using insecticides
6. Applying biological control (e.g. releases)
7. Cultural/agronomic practices

In this exercise we learn how to select studies and exercises to be conducted with farmers and how to adapt the studies to local conditions. It will help to use our creativity in preparing suitable studies and it will help thinking about how farmers will perceive a study.

#### **Method:**

1. Each group will visit a field (fields of different stages and different conditions for each group).
2. Visit the field and prepare a summary agro-ecosystem analysis, from ten sampled plants in the field, with information on the condition of the crop, the soil, the weather, water availability, agronomic practices, and pests, diseases and natural enemies.
3. Each group designs two studies that are relevant and feasible under the local conditions found. The studies should be from two different categories (see above). Show creativity, the methods and numbers (number of pests/defenders, number of replicates) you propose do not have to be exactly as conducted in earlier training and you could think of totally new studies on topics not yet covered in the training.
4. Discuss whether a feasibility study is required. IPM trainers should always have experience with each study they introduce to farmers. This will avoid unexpected problems. If the proposed study is new, a trial - or feasibility study by the trainer himself is required before doing the study with farmers.
5. Prepare a report on charts; one chart for the agro-ecosystem analysis, and one chart for each study. Present the objectives of each study, the materials needed and methods of the study.
6. Present the report with charts for everybody to discuss.

#### **Questions:**

1. Is the proposed study an important one when we consider the current field situation?
2. Is the study likely to give simple and clear results from which we can learn?
3. Will farmers be able to conduct the study?
4. Are farmers likely to understand the aim of the study?
5. What will farmers learn from this study?

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<sup>♥</sup> In the first season of farmer training in the Farmer Field School, the field study would normally focus on management practices especially IPM and farmers' practice (FP). When farmers would have gained basic research skills and the interest in learning further has been stirred, the farmers themselves will be able to design their own studies to address field problems.

6. At what times do observations have to be made and how does that fit into FFS sessions (for example, if observations have to be made over some period of time, how would you propose that farmers do it?)

## PART IV. SIMPLIFIED STATISTICS

Adopted from the Indonesia IPM National Programme

### **Background**

In pilot studies on weeding in soybeans in Indonesia, farmers commonly evaluated the averages per treatment without observing the variation among the three replicates. Consequently, faulty or premature conclusions were drawn in several cases. To help farmers evaluate whether differences between treatments were clear or not, a simple test was developed that encouraged farmers to evaluate the variability of their data. These “Simplified Statistics” consist of three steps (see below). Step 1 considers only averages per treatment; this is the only step farmers took in analyzing results during the pilot study. Steps 2 and 3 consider variation between replicates. In step 2 farmers determine for each replicate which treatment wins and which loses; if a treatment consistently wins in all replicates it is clearly better than the treatments. In step 3, farmers draw the minimum-maximum range of values for each treatment. If treatments have no values in common they are clearly different. Step 3 is more rigid than step 2; if the difference between treatments is consistent, their minimum-maximum values may still overlap. This test works satisfactory for studies with 3 - 4 replicates, but the chance of overlap between treatments increases with the number of replicates.

The test was applied to the results of the 29 farmers’ experiments. The outcome of the “Simplified Statistics” was identical to Tukey’s honestly significant difference ( $P < 0.05$ ) in 80% of the experiments. In five experiments (or 17%), the two tests differed in their level differentiation, with Tukey’s HSD test being most sensitive. In one experiment (or 3%), a significant effect was found with the Simplified Statistics but not with Tukey’s HSD. Thus, for studies with three replications, the Simplified Statistics test is comparable to Tukey’s HSD. Simplified Statistics will help farmers making better conclusions about their results. We observed in various occasions that farmers were able to use the test on their own data.

### **Guidelines for simplified statistics for farmers**

Three steps of Simplified Statistics for farmers:

**Step 1: Is the difference large?** To compare the average yields or outcomes of each treatment: Is the difference between the averages large ( $> 10\%$ ) or not? Normally farmers only use this first step.

**Step 2: Is the difference consistent?** In this step we look at the individual replicates or blocks (per row) to determine which treatment has the highest value (this treatment “wins”) and which the lowest (this treatment “losses”). If the same treatment “wins” in each replicate (for studies with 3 - 4 replicates), it is a consistent winner. If a treatment loses in each replicate it is a consistent loser.

**Step 3: Is there overlap between the minimum and maximum?** This is the most important step. Now, we look at individual treatments (per column) to find out the replicate with the minimum and the one with the maximum value. We do this for each treatment and draw the range of values for each treatment (as indicated in the drawing). Is there an overlap between treatments or not? (even if treatments have only one value in common, there is still an overlap). If there is no overlap between 2 treatments, those treatments are clearly different. If there is an overlap, the difference is not clear.

Step 2 is not really necessary, but increases understanding of variation. Step 3 determines the rigor of the test. This test works properly for studies with 3 - 4 replicates (as blocks); the results are comparable to traditional statistics.

If treatment values are consistently different but there is an overlap, the difference is not clear.

**Examples:**

Suppose a simple farmers' study on weeding in soybean, with only two treatments: local weeding practice and intensive weeding. Each treatment is replicated three times.

Replication 1	Local	Intensive
Replication 2	Intensive	Local
Replication 3	Local	Intensive

At harvest, the farmers take yield samples from each plot. Together with their field school facilitator, they prepare the following table of results (in t/ha):

	Local	Intensive
Replication 1	2.0	2.4
Replication 2	2.3	2.2
Replication 3	2.2	2.3
(Average)	(2.17)	(2.30)

The farmers are a bit confused with these data. Apparently, the intensive weeding treatment has a higher average yield, but is this difference really clear? The facilitator helps farmers using Simplified Statistics to draw a conclusion.

**Step 1: Is the difference large?** Yield in the intensive treatment is one-fifth higher than in the local treatment. This is at least a moderate difference.

**Step 2: Is the difference consistent?** In replicate 1, the intensive treatment wins (indicated with underlining); in replicate 2, the local treatment wins; in replicate 3, the intensive treatment wins. Therefore, no treatment is a consistent winner (or the difference between the treatments is not clear).

	Local	Intensive
Replication 1	2.0	<u>2.4</u>
Replication 2	<u>2.3</u>	2.2
Replication 3	2.2	<u>2.3</u>
(Average)	(2.17)	(2.30)

**Step 3:** Is there an overlap between minimum and maximum between the treatments? (after step 2 has shown that the difference is not consistent, step 3 will automatically show that there is also no overlap between the treatments; but let us conduct this step anyway).

First we draw the range of values for each treatment, from minimum to maximum value.

Local                    2.0 -----2.3

Intensive 2.2 -----2.4

The minimum value in the local treatment is 2.0, and the maximum is 2.3. In the intensive treatment the minimum is 2.2 and the maximum 2.4. If we draw these ranges, it appears that there is an overlap of values!! Therefore, the treatments are not clearly different.

**THE CONCLUSION IS THAT, ALTHOUGH THE AVERAGES DIFFER, THIS DIFFERENCE DOES NOT CONVINCE US (YET) THAT INTENSIFIED WEEDING INCREASES YIELD OF SOYBEAN. FARMERS COULD STICK TO THEIR LOCAL PRACTICE, OR REPEAT THE STUDY.**

**Ask groups to try out the following exercise on the simplified statistics method**

Yield results of a study on urea fertilizers in soybean are shown below.

1. Analyze with Simplified Statistics.

	<b>1 No urea</b>	<b>2 Urea 50 kg</b>	<b>3 Urea 100 kg (Local)</b>
Replication 1	4.71 kg	3.82 kg	3.41 kg
Replication 2	6.15 kg	4.61 kg	3.10 kg
Replication 3	5.34 kg	5.11 kg	3.74 kg
<b>Average</b>	<b>5.40 kg</b>	<b>4.51 kg</b>	<b>3.42 kg</b>

2. What is your conclusion?

3. Now, we look back at observations made during the season in those three treatments, in order to find out WHY differences in yield occurred. Try to relate the results of observations to the yield results.

<b>Main observations</b>	<b>Treatment 1</b>	<b>Treatment 2</b>	<b>Treatment 3</b>
Number of leaves	130	156	198
Plant height	42 cm	47 cm	49 cm
Number of pods per plant	26.7	20.6	20.2
Plant weight	19.6	20	19.0
Pests	more aphids, but levels are not serious; other pests are not affected		
Natural enemies	same in all treatments		
Weeds	few	normal	normal





# **Economic Threshold Levels**



## ECONOMIC THRESHOLD LEVELS

### *Background*

The goal of IPM training is to empower farmers to make their own decisions. These decisions are usually economic decisions about pest control - if I don't spray, will I lose some yield that is worth more than the cost of the spray? The decision requires knowledge of the ecosystem: recognition of pests and natural enemies, understanding of the interaction of pests and natural enemies, the crop and its ability to compensate. The decision also requires knowledge of the effect of pests on yields and the effect of pesticides on natural enemies.

We have seen that sampling is the first step in making decisions. This is the step of getting information. Using Economic Threshold Levels is the second step. Assessing the risk of pest populations is part of the economic step that begins the third step of the analysis. In the next section we will explore the meaning of Economic Threshold Levels and look at risk assessment when pest populations have surpassed their ETL.

**WE WILL ANALYZE WHY FIXED ETLs ARE NOT USEFUL AND WHY FARMERS' UNDERSTANDING OF THEIR AGROECOSYSTEMS IS MORE USEFUL FOR DECISION MAKING.**

## WHAT IS THE ECONOMIC THRESHOLD LEVEL?

### **Introduction**

The Economic Threshold Level (ETL) is an attempt to improve decision making practices by using partial economic analysis on the impact of a control practice, such as spraying a pesticide. The ETL is computed usually based on three parameters using the following equation:

$$\text{ETL} = \frac{\text{management costs (VNdong/ha)}}{\text{commodity value at harvest (Dong/ha) x damage coefficient(kg/ha/#pest/ha)}}$$

At the ETL the benefits of spraying are equal to the losses caused by the insects in the field. There are many ways of making this definition, but they are usually based on the same parameters.

What is the use of the ETL? Traditionally, when the ETL was surpassed (field populations are sampled and found to be higher than the ETL) the farmer was advised to spray.

IPM now includes a larger analysis of the ecosystem (like the IPM being taught in the field!). Other factors including levels of natural enemies, plant health and ability to compensate for damage, other investment opportunities, personal health, and weather are involved in the decision making process. The ETL is still a useful part of the analysis, but the ETL is not the only analysis.

In this activity we will explore the behaviour of the ETL given many scenarios. In the following exercises we will further explore other types of thresholds, decision making, and ecosystem analysis.

### **Objectives:**

- Define ETL (including parameters for computation)
- Demonstrate how ETL changes with changes in at least two of the parameters (commodity value and cost of control)
- Discuss why the traditional fixed ETLs are not useful when one considers other factors in the ecosystem like natural enemies, crop stage, etc.

### **Time required:**

120 minutes

### **Materials:**

Paper and pencil, bar charts

### **Method (for groups of 5):**

1. Each person in the group prepares one bar chart.
2. Each group should sit together in a circle. One person will be the secretary to record discussions.
3. Each person in the group should now adjust the two bars of the chart to reflect their definition of the ETL. The left bar reflects the cost of controlling pest (Dong/ha: usually cost of one spray), and the left bar the loss due to pests present (Dong/ha).
4. Each person should use the chart to define their idea of the ETL. Go around the circle and let each person say their definition aloud.
5. Now go through the following questions and movements of the bars:
  - a. The total costs of application include labour, chemical, transport, equipment, etc. How does the chart change if the cost of pesticides and labour increase? Does the other bar change position to maintain the definition of the ETL? What is the effect of increase of control cost to the ETL?
  - b. If you invest Dong 50,000, how much profit do you expect from your investment? If you spend Dong 70,000 for pesticide control, how much profit do you expect to receive? Would you ever

## *Economic Threshold Levels*

spend Dong 70,000 today to receive Dong 70,000 two months from now? Is this good business? Is this what the ETL means?

- c. On your chart, if your losses due to pests are going to be Dong 100,000 how much are you willing to spend for pesticides to protect from that loss? What if that pesticide money is invested for chickens, or in the bank, how much profit should you receive?
  - d. Do farmers have other economic activities besides vegetables? Do they have to use their money for maximum production of vegetables or for maximum profit from their money resources? What is the best management for a farmer with only small amounts of cash?
  - e. A problem: You have a pest infestation at the ETL in your field, and have to pay for your children's' schooling. Unfortunately you have only enough money to pay for controlling the pests or for the school. Which one will you choose? What if the extension worker tells you have to spray because the ETL is reached in your field?
6. Now go to step 4 and repeat defining the ETL. Is it different? What are the parameters for computing the ETL? How does the ETL change with increase in pesticide cost? Since you are an extension worker, have the pesticide prices changed? Have "official" ETLs changed?
  7. How is the ETL useful? Why do some farmers ignore recommendations to control pests when the pest population equals the ETL?

### Find the Appropriate Economic Threshold Level

VND 100,000 /ha		
VND 96,000 /ha		
VND 92,000 /ha		
VND 88,000 /ha		
VND 84,000 /ha		
VND 80,000 /ha		
VND 76,000 /ha		
VND 72,000 /ha		
VND 68,000 /ha		
VND 64,000 /ha		
VND 60,000 /ha		
VND 56,000 /ha		
VND 52,000 /ha		
VND 48,000 /ha		
VND 44,000 /ha		
VND 40,000 /ha		
VND 36,000 /ha		
VND 32,000 /ha		
VND 28,000 /ha		
VND 24,000 /ha		
VND 20,000 /ha		
VND 16,000 /ha		
VND 12,000 /ha		
VND 8,000 /ha		
VND 4,000 /ha		
VND 0 /ha		
	Cost of Application per ha	Crop loss (VND/ha) due to given population

50 /plant
48 /plant
46 /plant
44 /plant
42 /plant
40 /plant
38 /plant
36 /plant
34 /plant
32 /plant
30 /plant
28 /plant
26 /plant
24 /plant
22 /plant
20 /plant
18 /plant
16 /plant
14 /plant
12 /plant
10 /plant
8 /plant
6 /plant
4 /plant
2 /plant
0 /plant

**Directions:** Cut out two bars. Cut chart along dotted lines so that bars can be inserted into the chart like a bar graph. Place shaded bar on left, and population bar on right. Follow instructions in text.

## VARIABILITY OF ECONOMIC THRESHOLD LEVEL

### Introduction

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$$\text{ETL} = \frac{\text{management costs (VNdong/ha)}}{\text{commodity price (Dong/kg)} \times \text{damage coefficient(kg/ha/#pest/ha)}}$$

At the ETL the benefits of spraying are equal to the losses caused by the insects in the field. There are many ways of making this definition, but they are usually based on the same parameters.

What is the use of the ETL? Traditionally, when the ETL was surpassed (field populations are sampled and found to be higher than the ETL) the farmer was advised to spray.

IPM now includes a larger analysis of the ecosystem (like the IPM being taught in the field!). Other factors including levels of natural enemies, plant health and ability to compensate for damage, other investment opportunities, personal health, and weather are involved in the decision making process. The ETL is still a useful part of the analysis, but the ETL is not the only analysis.

In this activity we will explore the behaviour of the ETL given many scenarios. In the following exercises we will further explore other types of thresholds, decision making, and ecosystem analysis.

### Objectives:

- Define ETL
- Discuss the variability of each factor of the ETL
- Explain why fixed ETLs are not useful

**Time required:** 120 minutes

### Materials:

Newsprints and markers

### Method: (for the big group)

1. Present the equation for ETL:

$$\text{ETL} = \frac{\text{management costs (VNdong/ha)}}{\text{commodity price (Dong/kg)} \times \text{damage coefficient(kg/ha/#pest/ha)}}$$

2. Go through each factor. Ask participants to explain what they know about each factor.

*Note:*

*Management costs:* depend on the type of management used (cheap or expensive), access to tools (owned or rented), labor costs (own or hired; time of the year), differences between provinces (near cities or far from cities), other conditions.

*Commodity price:* stable for rice, but may change by a factor of ten during the year, and change from place to place depending on markets, etc.

*Damage coefficient:* varies according to the variety, water availability, natural enemy populations, weediness of the field, nutrient levels, weather, farmer skillfulness in growing the crop, disease infection, stage of the plant, plant spacing, etc. Not all damage leads to yield loss.



**(for small groups):**

- Now each small group will calculate ETLs for different situations for two farmers. Management costs for each of the farmers should be different: own vs. hired labour, cheap or expensive pesticides, close to or far from shop, own sprayer or rented, etc. List down all the management costs for Farmer A and Farmer B.

You can use the following table.

Management costs (VND/ha)	Farmer A	Farmer B
Labour		
Pesticides		
Transportation		
Sprayer rental		
Environmental costs		
Health		
Others		
	Cost:	Cost:

Also list down the commodity price for vegetables in different months of the year. The damage coefficient used in the exercise is:  $0.1 \text{ kg/m}^2/\text{insect/m}^2$ .

Month	Commodity price (VND/kg)		Computed ETL Given: $1 \text{ kg/ha}/1 \text{ insect/m}^2$	
	Farmer A	Farmer B	Farmer A	Farmer B
January	Price:	Price:	Loss:	Loss:
February	Price:	Price:	Loss:	Loss:
March	Price:	Price:	Loss:	Loss:
April	Price:	Price:	Loss:	Loss:
May	Price:	Price:	Loss:	Loss:
June	Price:	Price:	Loss:	Loss:
July	Price:	Price:	Loss:	Loss:
August	Price:	Price:	Loss:	Loss:
September	Price:	Price:	Loss:	Loss:
October	Price:	Price:	Loss:	Loss:
November	Price:	Price:	Loss:	Loss:
December	Price:	Price:	Loss:	Loss:

Calculate ETLs (# insects/ha) for each farmer for the different months.

For example:

$$\text{Farmer A, ETL (\# insects/ha)} = \frac{\text{Management costs Farmer A}}{\text{Commodity price Jan.} \times \text{damage coefficient}}$$

Make graphics of the ETLs for each of the farmers. On the X axis write the months. On the Y axis write the ETL.

- Present your findings to the group and discuss.

**Questions:**

- Is the ETL fixed for the whole season? Why does it vary? If a farmer has higher management costs, what happens to the ETL? If the commodity price is lower, what happens to the ETL?
- Do you think that a single ETL is useful for farmers? What factors do farmers have to worry about as well? On what factors will a farmer base his management decision?

### *Economic Threshold Levels*

3. For the damage coefficient, do you think that it can be a fixed number? Why or why not? What other factors should be included? Is it possible to determine a single ETL for many locations? Why or why not?

# BETWEEN ECONOMIC THRESHOLD LEVELS AND ACTION: RISK ASSESSMENT

## *Introduction*

The economic threshold is the population density (no. pests / unit area) which is causing as much economic damage as would be needed to control the pest. For example, the "official" ETL suggests that an average population density of three-four DBM larvae per plant will reduce yield (VND/ha) by the amount of money that it will cost to control the insects (VND/ha).

The threshold however is only a partial guide for decision making. You have seen in an earlier activity that the economic threshold changes with changes in prices of commodities and controls. Also you have discussed that other factors are included in decision making (natural enemies, investment opportunities, weather, etc.). Indeed, farmers usually have a shortage of money and are looking for the best opportunities for investing their money for maximum return on the money.

So what is the action that should be taken when the economic threshold is reached? This is an important question to answer since the academic answer ("spray when at the threshold") is not appropriate for the reality of farmers.

Risk assessment is part of making a decision after the ETL is reached. What will happen if I don't spray? What will happen if I do spray? Are natural enemies sufficient in the field? Will the weather change this week? Are there opportunities for controlling the problem?

The answers to these questions and to determine what you will do next begins with an understanding of the ecosystem. Understanding the interactions between weather, plants, herbivores, and natural enemies allows you to be able to predict which outcomes are most likely. For an experienced person, the ability to guess the outcome is due to both an understanding of the ecosystem and experience with similar situations.

In this activity we will develop scenarios and futures. These will be used to use your knowledge of interactions in the ecosystem to assess risk and outcomes in the future. Analyzing systems will improve your skills at risk assessment.

## **Objective:**

Assess the relative risk to a field given a set of ecosystem factors and assuming an economic threshold has been reached

## **Time required:**

120 minutes

## **Materials:**

Large paper, markers

## **Method (for groups of five persons):**

1. Copy the following chart on your large piece of paper:

<b>FACTOR</b>	<b>ODD</b>	<b>EVEN</b>
1. natural enemies	many	none
2. variety	resistant	susceptible
3. weather	sunny	cloudy
4. immigrants	few	many
5. age of insects	young	old
6. disease	few	many
7. rats	few	many

## *Economic Threshold Levels*

2. The next step is to choose one insect per group, which occurs in tomato, cabbage and/or French bean. Each group chooses a different insect.
3. Each person should now pick two numbers that have seven digits. Write the numbers on a piece of paper.
4. Now you are going to create futures! Take your number to describe the future by using each digit to choose the condition of each factor. If the first digit is odd, then in your future you have many natural enemies. If it is even then you will not have any natural enemies. If the second digit is odd, then you will have a resistant variety. If the second digit is even, then your variety is susceptible. Use your number to determine the future.
5. Now each person should analyze what he/she will do about a pest population that is above the ETL and has the future given above.
6. What other information is useful for making a decision? Is "do nothing" a kind of action? Or is "observe again in one week" a better action? What combinations of odds and evens are possible to say that "observe again in a week" is a good action?

You can also use this exercise for risk assessment of diseases.

### **Method (for groups of five persons):**

1. Copy the following chart on your large piece of paper:

<b>FACTOR</b>	<b>ODD</b>	<b>EVEN</b>
1. variety	resistant	susceptible
2. weather	sunny	rainy
3. humidity	low	high
4. wind	weak	strong
5.% diseased plants	low	high
6. lesion type	not sporulating	sporulating
7. pest	few	many
8. natural enemies	many	few
9. rats	few	many

2. The next step is to choose one disease per group, which occurs in cabbage, tomato and/or French bean.
3. Each person should now pick two numbers that have seven digits. Write the numbers on a piece of paper.
4. Now you are going to create futures! Take your number to describe the future by using each digit to choose the condition of each factor. If the first digit is odd, then in your future you have many natural enemies. If it is even then you will not have any natural enemies. If the second digit is odd, then you will have a resistant variety. If the second digit is even, then your variety is susceptible. Use your number to determine the future.
5. Now each person should analyze what he/she will do about a pest population that is above the ETL and has the future given above.
6. What other information is useful for making a decision? Is "do nothing" a kind of action? Or is "observe again in one week" a better action? What combinations of odds and evens are possible to say that "observe again in a week" is a good action?

**Ecosystem**



## WHAT IS THIS?

### **Introduction**

The goal of training is to provide an educational opportunity for participants. The methodology of training is very important for achieving the goal of education. One important method of training is to ask questions that allow the participants to develop their own analysis and understanding. You are stealing an opportunity for education if you reply directly with an answer. Ask questions.

Lead the participant to the answer by asking questions. In the field a common question is "What is this?"

There are many ways to answer the question "What is this?" For most of us, the natural response is to give the name of the object, often in a foreign language (Latin or English). The question is often answered by saying, "Oh that is *Lycosa pseudoannulata*" or "This is *Phytophthora infestans*". The result of this answer is that an educational process has been stopped.

A better way to answer the question is to ask a question: "Where did you find it? What was it doing? Were there many of them? Have you seen this before?" The idea is to promote learning by discovery and to lead persons toward their own analysis.

### **Objective:**

Give several kinds of responses to the question "What is this?" (None of the responses should be its name.)

### **Time required:**

60 minutes

### **Materials:**

Cabbage, tomato or French bean field, plastic bags

### **Method:**

1. Go into a cabbage, tomato or French bean field in groups of two or three persons.
2. In the group, take turns in the following roles:  
The "questioner" should take anything in the cabbage/tomato/French bean ecosystem (plants, insects eating plants, predators, parasites, dead things, anything!) and ask "What is this?" One member will act as a "recorder" and must write down the responses to the questions.

The "answerer" should respond with one of the following type of responses:

- "That is a good question. Where did you find it? What was it doing?" (Keep asking questions.)
- "I don't know. Where did you find it? What was it doing? Did you ever see it before? What do you think it is?" (Keep asking questions.)

Use this especially when you know what the specimen is. Try not to give the answer!

If the question is to be answered, the "answerer" should avoid answers that give more emphasis to identification. Rather, the function of the organism should be emphasized:

- "This is an insect that feeds on the plant. It is not really a problem insect until there are very many. There are many things which eat this insect including spiders and parasites."
- OR "This is a spider that eats insects and is a friend. It happens to be called a hunter because it moves around the field searching for insects."
- OR some other response that only gives biological/ecological information.
- OR encourage the participant to do some small study or experiment to find out more.

NEVER GIVE THE ANSWER WITH A NAME. THAT ONLY KILLS THE QUESTION.  
THE QUESTION IS A CHANCE TO LEARN.

3. After the members have taken their turns, return to the session hall/shade and process experiences.

**Discussions:**

1. How often do you usually give just a name for an answer? Do you think it is helpful in training to ask questions to assist in learning?
2. In your usual job, is helping farmers learn an important aspect in day to day work? Do you think it would be useful to answer questions with questions to help farmers?
3. Many field workers think they have to be smarter than farmers, even though the farmer is much older and more experienced. Do you think this method can help you in working with older farmers by facilitating the education process? Can you also learn from farmers by asking questions? Do farmers think respect, a desire to learn, or an instant answer is most important for a government worker?



## **ECOLOGICAL FUNCTION OF ORGANISMS**

### ***Introduction***

In the activity "What is this?" learning to answer questions with questions was emphasized. The response could be any question about the specimen. In the vegetable ecosystem, however, everything has a function, and the function is more important than the name. There are different levels of functions in all ecosystems.

The *first level* is the producer of organic materials: the plants. Plants include vegetables and weeds. The weeds have an additional function in the field. Weeds are also competitors for water, nutrients, sunlight and space. "Weeds" are defined in many ways, but one good definition is "a producer that is not wanted by mankind at that time and place".

The *second level* are organisms that feed on the plant. These include insects, rats and diseases. These are usually referred to as "pests". But "pests" are defined by their populations, not by their function. For example, when a population of diamondback moth reaches a high level that damages the cabbage, then the DBM is a pest. If the population is low, then they are not pests. They are food for natural enemies in this case.

The *third level* are organisms that feed on the second level. These include spiders, insects (predators and parasites), virus that attack insects, plant fungi and bacteria, owls, cats and other predators of rats. These organisms are usually called "natural enemies" or "friends of the farmer" because they attack things that could become pests. Preserving these organisms is important to keep the second level from increasing.

The *fourth level* are the decomposers and scavengers. These include bacteria, fungi and insects that feed on the dead plants, insects, spiders, rats, etc. that are in the vegetable ecosystem. These organisms cycle the nutrients in the system back into the soil. They can also serve as food for the natural enemies.

In this activity we will practice identifying the function of organisms found in the cabbage, tomato or French bean ecosystem. This is a good introductory activity for the study of ecology by farmer groups or students.

### **Objective:**

Explain the function of specimens found in the cabbage, tomato or French bean ecosystem

### **Time required:**

90 minutes

### **Materials:**

Cabbage, tomato or French bean field, plastic bags, alcohol, glue and large paper

### **Method:**

1. Go into a cabbage, tomato or French bean field in groups of two or three persons.
2. Each group should collect as many different types of organisms in the cabbage tomato or French bean ecosystem. Include plants, plants with disease, insects, spiders, rats, snakes, etc.
3. Go to a shady spot. Add alcohol to the plastic bag and shake the bag so that the insects and spiders die.
4. Discuss and separate the collected organisms by their function in the ecosystem. Place them in levels with plants at the bottom, plant feeders at level 2, natural enemies at level 3, and decomposers at level 4. Glue them onto the paper. If uncertain of the function, ask the trainer, or glue on the paper and label "uncertain".
5. Were there many organisms of each level in the cabbage/tomato/French bean ecosystem?

6. Could all plants be called "weeds"? Why or why not? Could all insects be called "pests"? Were there many level 4 decomposing insects in the fields?
7. Present the specimens to other groups, and describe the function and relationships between each level. Use descriptions of functions such as:
  - "This is an insect that feeds on the plant. It is not really a problem insect until there are very many. There are many things which eat this insect, including spiders and parasites."
  - OR "This is a spider that eats insects and is a friend. It happens to be called a hunter because it moves around the field searching for insects".

## **CONCEPT OF ECOSYSTEM**

### ***Introduction***

IPM is based on ecological interactions between the environment, plants, herbivores (diseases, insects, and rats) and natural enemies of herbivores (spiders, parasites, snakes, etc.) The health of the plant is determined by the environment (weather, soil, nutrients) and the herbivores. The herbivores are balanced by their natural enemies.

Many of the vegetable crops being grown in Vietnam were brought into the country with the herbivores but without their natural enemies. Furthermore, the adoption of input intensive agriculture has greatly influenced the interactions of the different components of the ecosystem. For example, the indiscriminate use of pesticides has led to resurgence of minor pests and resistance of other pests.

We need to start looking at the vegetable ecosystem from the view-point of maximizing profits without destroying the system. We need to understand the interactions and components. In this exercise we will look at the cabbage, tomato or French bean system interactions.

### **Objective:**

Demonstrate the function and balance of the components of the cabbage, tomato or French bean ecosystem

### **Time required:**

120 minutes

### **Materials:**

Markers, glue, scissors, paper, ruler, drawing board, plastic bags

### **Method:**

1. Assign each group (groups of five) to different stages of the vegetable crop (if available). If there is a newly plowed or harvested one, assign a group to this field.
2. For 30 minutes, let each group take an area of one square meter and record all kinds of plants, insects and spiders seen in the cabbage, tomato or French bean field. Let them collect the specimens in plastic bags. Use a net to catch more small insects and small wasps. Repeat the procedure in another 1m<sup>2</sup> plot.
3. If the farmer is present, inquire about additional information as fertilizer use, pesticide use, and so on.
4. Return to the session hall/shade and group the things collected from the field according to similarities, e.g., weeds, different insects as pests and natural enemies. Let them draw the things they have seen in the field on newsprint. Things with similar functions must be drawn near each other.  
Another procedure that can be followed is for participants to write the names of things seen in the field on small paper (2 X 5 cm). Add papers with names "sunshine", "rain", "high fertilizer", "low fertilizer".
5. Discuss with group members how the parts interact. Paste the names of ecosystem components on the big paper, and draw lines between all the components that interact. Explain what the lines mean.

### **Discussions:**

1. What are the major components of the ecosystem?
2. Discuss in small groups and present answers about what happens to each component over one season when:
  - a. A spray is used that kills all insects and spiders. Then pests migrate to the field.
  - b. The plant is resistant to all pests, so that no pest is in the field.
  - c. A high dose of fertilizer was applied to the plant and the weather is sunny.

- d. A high dose of fertilizer was applied to the plant and the weather is rainy and cloudy.
- e. The plant dies.

## **ECOSYSTEM ANALYSIS**

*Note: Questions for discussions are found in separate portions of the field guide for each crop (Part II).*

### **Introduction**

Decision making in IPM requires an analysis of the ecosystem. We have seen how sampling, and thresholds are important parts of that analysis. (Old IPM practices relied on economic threshold levels to make decisions. ETLs however, are extremely limiting and do not include the other factors in the ecosystem or farm management.) We have also discussed how some parts of the ecosystem interact (the plant, herbivores, natural enemies, diseases, weeds, the weather, and water conditions, etc.) Now we will begin to use a method of Ecosystem Analysis to facilitate discussion and decision making.

Ecosystem Analysis is a way of assembling what we are studying and placing it into a process useful for decision making based on many factors. The Ecosystem analysis will be done weekly, following monitoring activities and studies of components of the cabbage/tomato/French bean ecosystem. The results of the field observations will be drawn on a large piece of paper using specific rules given below. The drawing will then be used for discussion. There are questions designed for discussion during each stage of the crop. **These questions are found in separate portions of the field guide for each crop (Part II).** After discussion it is important that the results are presented to other groups. Everyone should be involved in the observations, drawing, discussion and presentation. Changing the person who gives the presentation each week is important to keep everyone involved.

### **Objectives:**

- Analyze the field situation by observation, drawing, and discussion
- Make decisions about actions required in the field

### **Time required:**

120 minutes

### **Materials (per group):**

Notebook paper, large-sized paper, pencil and drawing crayons, marking pen, graphing paper, plastic bags

### **Method:**

1. Go to the field. Walk diagonally across the field and choose ten plants. For each plant follow this examination process and record your observations. This should be done for each plot.
  - Plants: Measure plant size. Count leaves (green, yellow).
  - Insects: Observe and count the different insect pests from the top to the bottom of the plants.
  - Disease: Look at leaves and stems. Observe lesions caused by diseases, and count the number of leaves with disease. Estimate the percentage of leaf area infected.
  - Natural enemies: Count the number of each type of predator and the number of larvae with parasites. Also collect insects from pitfall traps.
  - Rats: Count number of plants damaged by rats.
  - Weeds: Note the type of weeds and count density of different weeds in the field.
  - Water situation: Observe and record the water situation in the field.
  - Weather: Record the weather situation.

2. Find a shady place to sit as a group. Each group should sit together in a circle, with pencils, crayons, data from each of the field activities (IPM, FP, No spray), and the drawing of the ecosystem of the previous week.
3. Now make a drawing on the large piece of paper. Everyone should be involved in the drawing. Make a drawing for each plot observed. There are several rules for drawing as follows:
  - Draw the plant with the correct numbers of leaves, flowers, fruits. Write the plant height, number of green and yellow leaves somewhere. If the plant is healthy, colour the plant green. If diseases occur, draw the diseases. If the plant is yellow, colour it yellow.
  - Draw dead or dying leaves in yellow.
  - For weeds, draw the approximate density and size of weeds in relation to the size of the cabbage, tomato or French bean plant. Draw the kinds of weed in the field.
  - For pest populations, draw the different insects found in the field on the right side of the plant. Write the average number next to the insect. Also write the local name next to the insect. The data can also be summarized in a table on the right side.
  - For natural enemy populations, draw the insects and spiders as found in the field on the left side of the plant. Write the average number of natural enemies and their local names next to the drawing.
  - For rats, write the average number of plants or fruits/heads attacked.
  - If the week was mostly sunny, add a sun. If the week was mostly sunny and cloudy together, draw a sun but half covered with dark clouds. If the week was cloudy all day for most of the week, put just dark clouds.
  - If the field was fertilized, then place a picture of a hand throwing N, P or K into the field depending on the type of fertilizer used.
  - If pesticides were used in the field, show sprays with a nozzle and write the type of chemical coming out of the nozzle. If granules were broadcast, show a hand with the name of pesticide being broadcast.
4. Below the drawing, provide space for general information, observations and recommendations.
  - General information includes the age of the plant, type of pesticide applied, variety planted, fertilizer used.
  - Observations include the general situation in the field such as water situation, density of weeds, presence of other pests and natural enemies seen but not found in the sample plant.
  - After the small group analysis, their recommendation for the week can be written.
5. Keep your drawings for comparison with weeks later in the season.
6. Now discuss the questions listed below for each stage of the plant depending on the crop observed. One person in the group is designated as the questioner (change the person each week). This person will ask questions about the field. Write your answers on the paper and add a summary as recommendation.

## *Ecosystem*

7. Each group should make a presentation of their field observations, drawing, discussions and summary. A different person should make the presentation each week.
8. Each group should plot the number of pests and natural enemies on a graphing paper. This should be done weekly to come up with a pattern of the weekly dynamics between natural enemies and pests.

## Ecosystem Analysis

<i>Steps</i>	<i>What to observe</i>	<i>What to ask - discuss</i>	<i>Actions</i>
1	Weather	Rainy? Dry? Trends in weather Dry/wet season Effects on crop	1. Do we need to water? 2. Do we need to prepare beds? 3. What disease management is needed?
2	Crop condition	Age of crop: Seedling Vegetative Flowering Fruiting Colour of leaves? Leafspots? Diseases?	1. Needs fertilizer? 2. Needs watering? 3. Needs fungicides? 4. What special topic should be discussed?
3	Field condition	Soil structure: Hard? Wet? Are weeds present?	1. Is hand weeding needed? 2. Is soil aeration needed?
4	Herbivores	What herbivores are present? What is their population? Are they damaging the crop?	1. Insect zoo 2. Special topic
5	Natural enemies (and neutrals)	What natural enemies are present? What is their population?	1. Insect zoo 2. Special topic
6	Activities in neighbours' fields	Did neighbours spray? What was sprayed?	Compare with FP plot
7	Decisions made last week	Was the decision made effective? Do we need to do a similar action?	1. Insect zoo 2. Special topic

### FINAL DECISION FOR THE WEEK BASED ON ALL 7 STEPS



# **Insect Zoo**



**Insect Zoos for  
Cabbage, Tomato and  
French beans**



## **INTRODUCTION**

Insect Zoo activities are done by participants in the training to help them learn about insects and natural enemies by direct observation and manipulation. Insects and spiders are more interesting when seen alive and active. A living organism is much more than what is seen in an alcohol filled jar. In fact some things can only be recognized when living.

The activity and behavior of insects and natural enemies can only be seen in live specimens. The Insect Zoo will give you many living specimens for demonstration that will keep farmers more involved and help them remember better that predators and parasites are friends in the field.

The Insect Zoo will also help you learn about the biology of the animal. Life cycles, egg laying, feeding, mating, growth and behavior can be learned directly through the process of rearing insects and natural enemies.

There are many ways to rear insects and natural enemies. Many parasites can be obtained directly from their host by collecting eggs, mature larvae, and pupae from the field and placing them in any plastic, glass or paper container. Place the collected specimens in the container and merely watch. If the specimens were parasitized, small wasps will emerge.

For parasites that are not collected from hosts, it is sometimes possible to put “sponge plant” in the field. This means that from reared insects you have plants in pots with egg masses or larvae. These plants with the host are placed in the field for up to four days to attract the parasites. The parasites will lay their eggs in or on the host. The “sponge” is then brought back to the pot and kept in a cage.

For other insects and spiders, collecting young nymphs, adult moths or spiders is the best way to begin rearing. However, for nymphs and for adult moths, you must have prepared plants ahead of time. For spiders, it is best to have lots of insect prey in a rearing cage before beginning to rear.

In this section on Insect Zoo, the following topics are included:

- Life cycles of main pests and natural enemies
- Life cycles and food webs
- Predation exercises
- Parasitism exercises
- Exercises on:
  - ⇒ *Spodoptera*
  - ⇒ Aphids
  - ⇒ Diamondback moth
- Insect collection

## **SOME BASIC EXERCISES TO LEARN ABOUT THE INSECTS**

### **I. Status of insects:**

Some insects are pests, feeding on plant parts. Others feed on insect prey. Again others come from weeds or neighbouring crops and are simply resting in the field. To find out whether an insect is a predator, collect it in a vial, give it some prey (aphids, eggs, small larvae) and observe whether it feeds; check again after some time. To find out if the insect is a plant feeder, give it different kinds of plants and observe whether it feeds; check again after some time. If the insect is unknown, give plants and other insects and observe. In all cases, place a piece of tissue paper between the tube and the lid to avoid condensation inside the tube. Close the tube. Keep tubes out of direct sunlight.

#### *Materials:*

Small plastic vials  
Tissue paper  
Fresh prey

### **II. Biology of insects:**

To find out about the developmental stages of insects, collect eggs, larvae/nymphs or pupae encountered in the field and rear them in vials through the next stages until they complete their life cycle. Feed the larval stage appropriate food (leaves, fruits, insect prey in case of predators) every day and observe the insects during development. Place a piece of tissue paper between the tube and the lid to avoid condensation inside the tube. Close the tube. Keep tubes out of direct sunlight.

#### *Materials:*

Small plastic vials  
Tissue paper  
Fresh prey or plant material

### **III. Reference collection:**

It is a good idea to build up a reference collection of pests and natural enemies during a field school season. To make a reference collection, pierce the dead insects with insect pins or fine tailor pins (pierce the pin through the thorax, the middle part of the body) and add a small paper label to the pin with details of the collection date, place and crop.

#### *Materials:*

Insect collection box  
Pins  
Naphthaline balls

## **LIFE CYCLES AND BIOLOGY OF PESTS AND NATURAL ENEMIES**

During the season we will rear pest insects and natural enemies to understand their life cycles. We can learn about the different stages of development of the insects and spiders, and how long it takes for them to complete their lifecycles.

### ***Materials:***

Vegetable plants (cabbage, tomato, or French beans), small plastic bottles, cages, plastic bags, brushes

### ***Method:***

There are many ways for rearing insects and spiders. Below are some general methods and specific tips for specific insects

#### *General rearing methods*

1. Bottles and plastic bags are very useful rearing tools. Always carry a couple in your pocket or bag. If egg masses, larvae or nymphs are found in the field, collect and place in a bottle or plastic bag. The bottle should have a piece of netting over the mouth. Add plant material daily for herbivores. Transfer to larger cages if necessary. Try to collect older larvae that will pupate quickly. Parasites will also emerge from egg masses, larvae and pupae.
2. Simple cages can be made using waste materials such as transparent glass or plastic bottles. Place leaves and stems in the bottles with insects and cover with netting. For soft drink bottles, place a bouquet of stems and leaves in the bottle and cover with a large plastic bag. For seedlings, invert the plastic bottles that have one end open and the other end covered with netting material.
3. Field cages are useful to cover infestations of larger larvae and other insects. Make cages from large plastic bags, or netting materials. Use bamboo sticks to hold the cages above the plant.
4. Potted plants and cages are useful especially for demonstrations and exhibitions. Grow your own plant in the pot, or transplant from field grown plants. For cages use netting suspended strings or frames, or use plastic bags with netting glued over one end. Expensive thick stiff plastic is also useful.
5. Be creative! It is surprising where insects can be reared. Use discarded cans for pots, and transparent plastic bottles for cages. Clear glass jars and small plastic containers will suffice for most needs.

Rear the following insects and spiders:

Diamondback moth

Flies

Leafminers

Aphids

*Spodoptera exigua*

*Spodoptera litura*

*Heliothis*

Spiders

Parasites

Coccinellid beetles

Chrysopa

Syrphid larvae

Peaderus adults

and other insects you can find in the field.

Observe regularly. Write down your observations in your notebook. Make drawings of different stages. At the end of the studies, summarize your findings on a big piece of paper. Draw the different stages of insect development.

Regularly present your results to the other participants in the training course.



## **LIFE CYCLES AND FOOD WEBS**

### **Introduction**

Life cycles of plants, insects and natural enemies are well known to us. The development from egg or seed to adult insect, spider or plant has been seen in the field and in the Insect Zoo.

Food chains are the interactions between plants, herbivores and natural enemies of the herbivores. The energy from one level of the ecosystem (plants) moves to another level (herbivores) along a chain of interaction.

As a trainer working with farmers, you must begin to integrate these two motions together into a smooth acting dynamic ecosystem. In this exercise, you will have to put the two systems together so that they are functional. This will help you to understand that interactions have a time frame. For example: the life cycle of caterpillars all begin with an egg stage. In the next stage, the larvae feed on the leaves by chewing. Finally adults mate and lay eggs on the same plant or migrate to other fields. During each stage, different natural enemies attack the caterpillars. During the egg stage, parasites complete their own egg/larva/pupa/adult in the eggs and kill the eggs. During the larval and adult stage, hunting spiders, lady beetles, and other predators feed on them. Parasites and other natural enemies act the same. Every life cycle is part of a food chain.

The combination of interacting life cycles of the plant, pests and natural enemies is a good view of the dynamic system of the cabbage/tomato/French bean field. It shows also that a balance is needed in the system to make each life cycle possible; for example, a spider life cycle depends on aphids. If there are no aphids then there will be no spiders to protect the field. In this system, insects such as aphids at low population are actually very beneficial to the farmer because they are spider food; and spiders are what protect the beneficial insect from large population changes. Did you ever think that an aphid might be a beneficial insect to the farmer? It all depends on how many are in the field. This can be explained now by looking at how the system interacts.

For this exercise, you will have to integrate much of your knowledge into a big picture. It will not be easy to put the pieces together. Also for this exercise you should think in terms of "guilds". Guilds are groups of organisms that have similar types of life cycles and share food sources and are usually attacked by the same natural enemies. Try to use major guilds for this exercise rather than individual species.

### **Objectives:**

- Explain the interaction of the ecosystem factors using both life cycles and food chains for at least one guild of insect pests
- Develop a concept of the food web and food chains
- Discuss the importance of food web and food chains in relation to ecosystem and pest management

### **Time required:**

120 minutes

### **Materials:**

Paper, pens, crayons

### **Method:**

1. Each group should choose a guild to analyze: leaf-eating caterpillars, leaf miners, aphids, etc.
2. Draw a large circle and write in the general stages for insects of the guild around the circle.
3. On one side make a list of the stages of the insects in one column. In the next column, make a list of natural enemies (by guild) which attack each stage. (Show that at each life stage of a pest, there is a corresponding natural enemy with its own life cycle.)

4. On the drawing, draw a circle for each natural enemy that attacks a particular stage of the insect. On the natural enemy circle, write the stages of the natural enemy's life cycle. If there are natural enemies of the natural enemies (example a spider that eats another spider) then make a third level of circles for these natural enemies.
5. After finishing the diagram, do a short role play on natural enemies and insect pests, if possible, working through whole life cycles and describe parts of predators that are important for their function as killers!

**Discussions:**

1. Explain life cycle, food chain, and food web.
2. How does food web relate to biodiversity?
3. How do you group different organisms involved in a food web in relation to the amount of energy consumed?
4. What would happen to the natural enemies if there were no pests?
5. Do you think insect pests can be beneficial at low populations? Why are they important?
6. What is the effect of pesticide application to the ecosystem?

## **DIRECT OBSERVATIONS OF CONSUMPTION RATES OF PREDATORS IN THE FIELD**

### ***Introduction***

Some predators are not so easily disturbed so we can study their natural feeding behaviour by simply observing them for a while in the field, and recording what and how many prey they eat during a certain period of time. Such observations take a lot of our patience, but with a group of observers (for example in a Training of Trainers course or a Farmer's Field School), we can obtain interesting results within a short period of time.

### **Materials:**

Hand lens  
Watch  
Whistle

### **Method:**

1. Early morning at 7 a.m., the trainees are briefed, and are divided into groups that will each observe a particular predator species in an unsprayed field. For French beans, the following may be observed:
  - A. Spiders
  - B. Coccinellid larvae (large instar)
  - C. Coccinellid adultFor cabbage and tomato, the following may be observed:
  - A. Syrphid larvae (large instar)
  - B. Coccinellid larvae (large instar)
  - C. Coccinellid adult
2. Each member of the group is required to find a predator of the appropriate species. When everyone has found a predator, a field leader gives a whistle to start the 10-minute observation. Everyone follows his predator and counts the number and sizes of the prey it eats within a ten-minute interval. The predators should not be disturbed and should not be given prey because we want to observe their natural feeding behaviour.
3. After ten minutes, the field leader gives a second whistle to end the observation. Everyone gathers and the results of everyone's observations are compiled on a board directly in the field. The average predation rates (per hour) are calculated for each predator.
4. The same activity is repeated at 9.30 am and (if possible) at 6.30 p.m. in order to compare the activity of predators at different times of the day.
5. After each observation, results are compiled and discussed in the 'field class'.

### **Discussions:**

1. How many prey can each predator eat per hour?
2. What is the preferred prey of each predator species?
3. Are there differences in feeding rates at different times of the day?
4. Which predator is the most active searcher?
5. When the pests are less common, would the predators eat the same numbers of prey or less? Why or why not?

## PEST DENSITY AND PERCENTAGE PARASITISM

### Method:

- In an unsprayed cabbage, tomato or French bean field, conduct sampling twice a week (i.e. every three or four days).
- Select 20 plants at random and record numbers of a specie of larvae and pupae, e.g., diamondback moth (*Plutella*) on cabbage, per plant.
- Also twice a week, collect ten mature larvae and ten pupae, and rear them individually inside plastic tubes until emergence of the moth or parasitoid. Provide some food for larvae and replace the food daily.
- Leaf pieces for food should be as small as possible to prevent condensation inside the tubes. Further, a small piece of tissue paper should be secured between the lid and the tube.
- Evaluate seasonal densities of larvae and pupae as well as the level of parasitism. Record and collect parasitoid species present.
- If possible, repeat the survey in other locations.

## **MEASURING THE PARASITISM LEVEL OF CATERPILLARS**

*(Note: The same insect zoo may be used to measure parasitism level on eggs and pupae.)*

### **Objectives:**

- Observe which parasitoids attack caterpillars
- Discuss the importance of parasitism
- Observe some aspects of the biology of the parasitoid species, for example, do they attack young or older stages of the host

### **When:**

Any time when caterpillars are common in the field

### **Materials (per group):**

Plastic tubes with labels

Tissue paper

Fresh plant material for larval feeding

### **Method:**

1. From an unsprayed field, each group should select two species of larva that are common and collect
  - five small
  - five medium
  - five largeof each species. If plenty of tubes are available each group could collect more larvae.
2. Put larvae individually inside plastic tubes and label the tubes with:
  - the date of collection
  - host species, and
  - size of host at collection
3. Add some fresh leaves as food and secure a piece of tissue paper between the lid and the tube to prevent condensation.
4. Observe each tube and replace the food daily. Observe carefully whether parasites emerge from the caterpillar, whether the caterpillar has pupated or whether the adult has emerged. If parasites have emerged, count them and keep them for identification.
5. Continue these observations until the end of the course, until parasites or adult moths have emerged, or until the host has died because of other reasons.
6. Calculate the intensity of parasitism for each stage (small, medium, large) of the host as follows:

$$\% \text{ parasitism} = \frac{\# \text{ parasitized larvae}}{\text{total \# larvae}} \times 100\%$$

7. Collections could be repeated weekly or every 14 days to study how parasitism levels change during the season. Make calculations for every sampling occasion and evaluate how parasitism fluctuated during the season.

### **Discussions:**

1. What parasites were found in the different larvae?
2. What were parasitism levels of each pest species?
3. Did you find different parasite species in the small and large stages of the host?
4. Describe how each parasite species developed in the tubes (e.g. was development mostly inside or outside host; how many parasites emerged per host; from which host stage did the parasite emerge).

## STUDYING PARASITOIDS IN THE FIELD

### Objectives:

- Recognize that parasitoids are present in the field
- Incorporate field information about parasitoids into ecosystem analysis
- Show that parasitoids are indeed friendly insects
- Guide other farmers to discover the value of parasitoids

### Materials:

Collecting kit consisting of clear plastic containers and bags  
One 10x magnifying glass or hand lens  
One camel or fine hair brush  
One pencil and paper for labels  
One note book  
One roll of tissue paper

### Method I:

#### Recognizing parasitoid activities

Parasitoids are usually small creatures and would be difficult to spot as they are fast flyers in search of suitable hosts. However, they leave evidence of their activities in the form of dead caterpillars or more commonly, cocoons. Often, farmers mistake these cocoons for eggs of insect pests. Hence, it is important to start understanding parasitoids by walking in the vegetable field and asking farmers to collect sick insects and round or egg shaped silken cocoons. During the collection, many egg masses of spiders and even insects caught in spider webs will be brought in. If the cocoons are found next to a dead or dying caterpillar, it is easy to show the connection between the cocoon and the caterpillar. For example, a white cocoon of *Cotesia plutellae* is usually found next to a dead caterpillar with a large hole indicating where the parasitoid larva emerged. This will indicate that we should collect many larvae of similar age to confirm if the parasitoid is from the caterpillar and witness the process of emergence from the caterpillar. Showing this to farmers will help farmers understand the importance of the cocoons. Placing these cocoons inside clear plastic bottles will allow farmers to observe what will emerge from these cocoons. Using coloured pencils, make drawings showing recognition of each of the cocoons and also the type of adults that emerged and the caterpillar parasitised.

### Discussions:

1. What is the colour of the cocoon?
2. How many cocoons developed from each caterpillar?
3. Where were the cocoons found on the plant?
4. How many cocoons did you find?
5. What emerged from the cocoons?
6. What type of cocoon is associated with which caterpillar?

### Method II:

#### Collecting information/field sampling parasitoids for ecosystem analysis

Very often, the natural enemies that are drawn in ecosystem analysis drawings are predators. It is important to include information on parasitism. There are two existing ways of studying parasitoids that are not very good - i.e. counting adults and breaking body of caterpillars to check for parasitoids. A better way to assess the population of parasitoids as part of an ecosystem analysis study is to count the number of fresh parasitoid cocoons in the field. Ignore the cocoons with holes as these indicate that the parasitoids have emerged. For a good ecosystem analysis, each parasitoid should be linked to the specific caterpillar that is attacked by the parasitoid.

**Discussions:**

1. What is the most common parasitoid cocoon found in the field?
2. How many of these are found per 10 plants?
3. Which herbivore (pest) is attacked by the adult from the cocoons collected?
4. Are there enough cocoons to produce parasitoids that will kill the specific pests?

**Method III:**

**Confirming the usefulness of parasitoids**

For farmers who are interested in learning more about the parasitoids they collected from the cocoons, please refer to the exercise on studying parasitoids. This should be encouraged as farmers often want to confirm the usefulness of each of the parasitoids and will ask question such as:

**Discussions:**

1. What is the host attacked?
2. What stage of the caterpillar is attacked?
3. What other kinds of caterpillars are attacked by a specific parasitoid?
4. How do we conserve these parasitoids?

## STUDYING PREDATORS IN THE FIELD

### Objectives:

- Try out two methods of collecting predators
- Carry out studies to observe predation in vegetable fields

### Materials:

Collecting kit consisting of clear plastic containers and bags (including empty film containers)  
One 10x magnifying glass or hand lens  
One camel or fine hair brush  
One pencil and paper for labels  
One note book  
One roll of tissue paper  
Cup with straight sides (12cm in height and 6cm in diameter)  
Liquid detergent  
Water

### Method I:

#### Using plastic bottles and brush

Go to the field and search for predators similar to those found in the rice fields. Collect them using clear plastic bottles (e.g. empty film containers) without touching the insects or else use the brush. Any unfamiliar insect on the vegetable plants should be collected and brought back to the meeting room for study. For each insect to be studied, place it inside a plastic bottle together with parts of the plant and some insect pests. Observe for three days and record whether the test insect feeds on plant or other insects. Experience will enable trainers and farmers to help other farmers understand which insect is a pest and which is a predator. Using similar methods as in rice insect zoo exercises on predators, trainers and farmers can determine the type of insect pest eaten by a specific predator, how many are eaten per day per predator and which stage of the predator is more active in feeding.

Besides using plastic bottles and hair brush to collect predators, trainers and farmers may use pitfall traps to determine what predators are active at the soil level and to provide an indication of the number of predators present.



**Method II:**

**Using a pitfall trap**

This is a cup with straight sides and about 12 cm height and six cm diameter. It is buried up to the lip in the soil, usually between two plants. Live predators can be collected if no water is placed inside the cup. However, if numbers of predators are to be assessed, place water mixed with some liquid detergent to collect all insects that fall into the cup. Check the cups in the morning after leaving it overnight. Predators caught in pitfall traps will help complement the visual counts of predators during field sampling.

**Discussions:**

1. What kinds of predators are present in the vegetable fields?
2. Which is the most common?
3. What are the insects eaten by each predator?
4. What is caught in the pitfall trap?
5. Are all arthropods that fall into the pitfall traps predators?
6. If not, what are the functions of such arthropods as collembolans and woodlice?
7. Are there more predators in pitfall traps as compared to visual counts?
8. Did you find a new predator in your study? Which stage of the pest does it eat?

## ASSESSMENT OF THE IMPACT OF GROUND-DWELLING PREDATORS

### Method:

- A few weeks after planting, select 30 plants with similar phenology and similar densities of insect pests, e.g., *Plutella* in cabbage.
- Randomly assign 15 plants as predator exclusion and 15 plants as controls. Mark the plants.
- Make exclusion barriers (zink sheets of 20 cm height with insect glue on the top) and secure them around each of the 15 exclusion plants. Cages made of wooden frames with fine netting material may also be used. Remove any predators inside the barrier or on the plant. Leave the insect pest, e.g., *Plutella*, undisturbed.
- Weekly record levels of insect pests in each treatment. Compare the treatments; continue until harvest.
- At harvest, compare yields for each treatment.

**Note:** By concentrating on ground predators, we are ignoring a possible density-dependent mortality due to parasitism. If percentage parasitism is higher at higher pest densities, parasites may compensate partly for a reduced predation level.

## **PREDATION ON SUCKING INSECTS IN INSECT ZOO**

*(You can conduct the same study with other pests, e.g., caterpillars as prey, using 3-5 larvae per vial.)*

Predators may feed on sucking insects in the field. To learn about their consumption rate we can conduct a simple study with predators that feed on small sucking pests such as aphids, leafhoppers or white flies.

### **Objective:**

Observe consumption rates of predators

### **Materials:**

Clear plastic or glass vials with lids (five per group)

Some tissue paper

Fine brush

Hand lens

Labels

### **Method (per group):**

1. Collect leaves in the unsprayed field plot with plenty of small sucking pests.
  - a. In case of aphids, remove the winged adults with a fine brush and remove any other insects so that ten aphids are left per leaf.
  - b. In case of leafhoppers or white flies, remove any other insects with a fine brush so that ten leafhoppers or white flies are left per leaf. Be careful not to damage the prey. Insert each leaf in a vial so that each group has four vials with ten each of the same prey species. Insert a single leaf without prey in the 5th vial (control).
2. Also collect different species of predators in the unsprayed field plot, with five individuals of each species. Each group could choose their own predator species, for example, spiders, black ants, coccinellid adults and larvae in French beans; syrphid larvae, Pederus adults, Coccinellid adults and larvae in cabbage and tomato.
3. Add one predator to each vial. Label the vials with date, time, group name, predator species and prey species. Place a piece of tissue paper between the vial and the lid to avoid condensation. Keep the vials in a shaded place (away from direct sunlight).
4. Observe the predators for a while to see if and how they feed on the prey.
5. After 24 hours, carefully count and record the number of prey (that are alive) inside the vial. Check whether you can retrieve any remains of pests that have been killed.

### **Discussions:**

1. How many pests did each predator consume in 24 hours?
2. Which predator species ate most and which ate least?
3. What happened in the control vial? What is the value of having a control without a prey?
4. Do predators behave differently inside tubes than when free-living in the field? Would the predators feed more in tubes in the laboratory or in the field? Explain why.

## SPIDERS

There are many insects and spiders found on the vegetable plant and on the beds and irrigation canals. Most of the insects are not pests or even potential pests. In fact they are beneficial to the vegetable farmer because natural enemies such as spiders feed on these non-pest insects. This is how spiders can survive even when pest populations are low.

In this activity, we will search for spiders and their prey. You should be able to explain where spiders are living in and around the vegetable field and what kind of spiders can be found.

### **Objective:**

Describe spiders in and around vegetable fields

**Time Requirement:** 1 hour and 30 minutes

### **Materials:**

Newsprint, pentel pens, test tubes and spiders

### **Method:**

1. Each group counts spider populations in a square meter area for example in/on the cabbage:
  - plot
    - a. seedling stage
    - b. stem and leaf development stage
    - b. head formation stage
    - c. harvest stage
  - side of the plot
  - grassy area near the vegetable field (2 meters from the vegetable field)
  - newly plowed field
2. Identify the kinds of spider species seen.
3. Consolidate and present data to the big group. Use the matrix below:

Spider species	Plot				Side of plot	Grassy area	Newly plowed	Total
	Seedling stage	Stem & leaf development stage	Heading stage	Harvest stage				

Total

### **Discussions:**

1. Where can you find the highest spider population in the four areas and why? The lowest, why?
2. What are the kinds of spiders found in the different areas?
3. What will happen to spiders when there are no pests present?
4. In what part of the vegetable plant are spiders commonly found?
5. How many insects does a spider eat in one day?
6. What are the characteristics of spiders?
7. Differentiate spiders from insects?
8. How does a spider eat insect pests? Do a role play.
9. What is a pest? If at low populations, spiders survive on some insects, are these insects pests? Does "pest" refer to an insect, a damage or an intensity of insect?

9. Get the average number of spiders in the different ecosystems surveyed and extrapolate population into per hectare basis. How many spiders are there in a hectare? If one spider can eat five to ten pests in one day, how many pests will they eat in one day?

Note: For FFS activities seeds could be used to determine the dynamics of spider population using the following assumptions:

Ratio of male and female	=	50:50
Birthrate	=	30 spiderlings
Survival rates:		
Group 1	=	0.1 percent
Group 2	=	0.3 percent
Group 3	=	0.5 percent
Group 4	=	0.7 percent
Group 5	=	0.9 percent

Compute for three generations. How many pests are consumed by spiders in each generation. Make a graph of the different survival rate data from each group.



# Insect Zoo for Cabbage





## **LIFE CYCLE OF THE DIAMONDBACK MOTH - *Plutella xylostella***

### **Objectives:**

- Explain the development of an insect with complete metamorphosis
- Carry out an insect zoo study to understand the life cycle of a butterfly/moth/beetle/fly

### **Materials:**

Collecting kit consisting of clear plastic bottles or bags  
Cages (with organdie material) and potted vegetable plants  
Sweep net to collect moths  
One 10x magnifying glass or hand lens  
One camel or fine hair brush  
One pencil and paper for labels  
One note book  
One roll of tissue paper

### **Methods:**

Have a few potted cabbage plants to carry out the study in a large cage or laboratory. In addition, there should be some insecticide-free plants in the field for the participants to collect the moth and other stages of the insect. To study egg-laying, collect moths from the field and place these inside a cage covering the potted plant. Allow the moths to stay with the plant for 24 hours. After 24 hours, remove the moths and observe for eggs laid on the plant. Answer the questions listed below and using a binocular-dissecting microscope or a 10x magnifying glass, make measurements. At all stages, make drawings and notes. To ensure satisfactory follow up, please label each tube by placing the paper labels inside each container.

Larvae and pupae may be studied using clear plastic or glass pill-boxes. Usually these are cylindrical tubes with about 2 cm diameter and 6 cm length with a snap on lid. Line the tube with slightly moist tissue paper and keep away from sunlight or hot place. Again answer the questions listed below. Make some questions of your own and suggest methods to carry out the studies to answer these questions. For example, will caterpillars become cannibals when food is scarce?

### **Egg stage:**

- Were the eggs laid on the plant or soil?
- If on the plant, on which part of the plant?
- If on the leaf, on which part of the leaf?
- If on the stem, is it a young stem or an older portion?
- Looking at the eggs, how many do you think are laid at one time?
- What is the shape of the egg?
- What are the colours of the eggs? Why are there differences in colour?
- How many days pass before the egg/s hatch into caterpillar/s?

### **Larval stage:**

- Where do you find the larva of the diamond backmoth?
- What is the size of the caterpillar when it hatches from the egg?
- What happens when the caterpillar grows?
- Does it change skin? If so, why does it change skin?
- How big will it grow?
- Does it remain on the same leaf or does it travel between leaves?
- If the caterpillar is found on the leaf, do you tend to find it on the lower or upper surface of the leaf?
- What happens when the caterpillar is full-grown?
- How many days will the larval stage last?

### **Pupal stage:**

Where does the caterpillar pupate?  
Does it make a cocoon?  
What is the colour of the cocoon?  
What is the function of the cocoon?  
What is the size of the pupa and cocoon?  
How many days will the pupal stage last?

***NOTE: This study is particularly suitable for insects that are easy to spot in the field. For smaller insects such as flies and leafminers, the whole leaf may be collected and placed inside containers and observed daily. It is hoped that this exercise provides a useful guide to study insects in vegetables. However, this will depend on participants experimenting with different types of insects and reporting on the innovative ways to overcome limitations such as humidity and diseases. When working with farmers, facilitators should monitor progress closely in case the experiment fails due to diseases or predation or if insects escape.***

## **LIFE CYCLE OF A SUCKING PEST - e.g., aphids**

*(This exercise can also be done in French beans.)*

### **Objectives:**

- Explain the development of an insect with incomplete metamorphosis
- Carry out an insect zoo study to understand the life cycle of aphids

### **Materials:**

Collecting kit consisting of clear plastic bottles or bags  
Cages (with organdie material) and potted vegetable plants  
Sweep net to collect insects  
One camel or fine hair brush  
One pencil and paper for labels  
One 10x magnifying glass  
One note book  
One roll of tissue paper

### **Method:**

Collect egg masses, nymphs and adults from the cabbage plants in the field. Keep them in glass or clear plastic containers lined with tissue paper and pieces of fresh cabbage leaves. To study the length of the egg stage, either collect freshly laid eggs from the field or keep pairs of adults together on potted plants. Observe the changes in the life cycle of the bug. Usually, plant-feeding insects complete their life cycles within three weeks.

### **Egg stage:**

- Where are the eggs laid?
- How many eggs are laid in a batch?
- How many days does it take for the youngest nymphs to emerge?
- What is the colour of the eggs?

### **Nymphal stage:**

- Do the young bugs that hatch from the eggs resemble adults?
- How is this different from the diamond backmoth studied earlier?
- Do you think there are differences in the development of insects?
- What is the colour of a newly emerged bug?
- What is the colour of an older bug?
- How can you tell that the bug has developed into an adult?
- How long does the nymph remain in the immature stage?
- Why does the immature bug change skin as it grows?

**NOTE:** *The exercises mentioned above represent two types of insect development and the studies would familiarize participants with the concept of metamorphosis. The information is useful when studying predation and parasitism. Moreover, the study will enable the trainers to learn entomology by discovery and therefore develop confidence when tackling insect problems. When working with farmers, facilitators should monitor progress closely in case the experiments fail due to diseases or predation or if insects escape.*

## FIELD RELEASE OF *DIADEGMA* PARASITES

(This should be done after the exercise on Measuring the Parasitism Level of Caterpillars.)

### Objective:

Experience releasing *Diadegma* cocoons or adults in cabbage fields

### When:

When there is evidence of early DBM infestation as seen in high percentage of unparasitized DBM larvae in the cabbage field

### Materials (per group):

*Diadegma* cocoons or adults

Five releasing boxes (if cocoons are to be released)

Cabbage fields with high DBM population

Notebooks and pens

### Method:

1. Monitor neighboring fields for parasitism level of DBM larvae. (**See earlier exercise on Measuring the Parasitism Level of Caterpillars.**) If the group observes that the level of unparasitized larvae is high and decides to release *Diadegma*, the following steps may be done.
2. Prepare about 500 - 750 *Diadegma* cocoons or adults for release in at least one (1) hectare of cabbage field. A releasing box is needed if *Diadegma* cocoon will be released.
3. Release the *Diadegma* parasites:
  - Place 100 - 150 *Diadegma* cocoons in plastic containers in each of the five release boxes strategically distributed in one hectare of cabbage field. OR
  - Release adults in five strategic points in one hectare of cabbage field.
4. Closely monitor the field one (1) week after the first release and determine the percentage parasitization.
5. Release another 500 - 750 *Diadegma* cocoons or adults per hectares if parasitization is less than 25%.
6. Monitor again after a week and undertake the third release if necessary.

### Discussions:

1. What was the initial level of parasitization on DBM? What was the initial *Diadegma* population in the field at the time of release of the parasite?
2. Compare the population of DBM before the first release and after a week. Did the *Diadegma* bring down the DBM population?
3. How many times did you release *Diadegma*? Compare the level of parasitization after two weeks. Compare again after three weeks. Was releasing *Diadegma* efficient and effective?
4. What are possible ways to involve farmers in this activity?

## **STUDYING PARASITOIDS OF THE DIAMONDBACK MOTH**

### **Objectives:**

- Explain how parasitoids search, attack and lay eggs in the host caterpillar
- Observe parasitoids search and lay eggs in selected hosts and even specific stages of the host
- Evaluate the survival rates of adult parasitoids
- Carry out studies to confirm activities of parasitoids in their fields
- Try out methods to effectively conserve these parasitoids.

### **Materials:**

Cages (with organdie material) and potted vegetable plants  
Sweep net to collect adults pests and parasitoids  
Plastic containers and bags (including empty film containers)  
Clean water  
Plastic cups  
An aspirator (for collecting small wasps by sucking into a tube)  
Small bottle of honey and sugar  
One 10x magnifying glass or hand lens  
One camel or fine hair brush  
One pencil and paper for labels  
One notebook  
One roll of tissue paper  
Mosquito net or organdie material  
Rubber bands  
Two small handheld sprayers  
Small quantities of any common insecticides used by farmers in the area

### **Method I:**

#### **Parasitism and stage of host**

Using caged potted plants, release some adult moths and keep for 24 hours. Remove the moths when eggs are found. Do the same for another pot so that we have seven pots with seven different days of exposure. This will supply caterpillars of different ages. Collect parasitoid cocoons from the field (e.g. *Cotesia plutellae*) and keep them in small plastic containers until the parasitoid emerge and feed with honey solution (50% honey and 50% water). There should be about 20 parasitoids living together in a cage for 24 hours. This will ensure mating and help the parasitoids to be ready to attack the caterpillars. Prepare a potted plant and collect caterpillars using hair brush - two caterpillars each from a pot six days after egg laying, eight days after egg laying, ten days after egg laying, 12 days after egg laying and 14 days after egg laying. If studying diamondback moth, also introduce armyworm caterpillars and other kinds of caterpillars together with the diamondback moth caterpillars (no more than two of each type of caterpillar and preferably the younger stage). Using an aspirator (or using a small clear plastic tube) collect five parasitoids from the parasitoid cage and transfer to the potted plant with caterpillars of different ages. Drop some honey solution on the leaves to feed the parasitoids. Keep the parasitoids with the caterpillars for 24 hours and watch what happens. After 24 hours, remove the parasitoids and rear the caterpillars to pupal stage. Each group should have a set of experiment.

### **Discussions:**

1. What happens when the parasitoids are introduced into the cages with caterpillars?
2. How long does it take before they find the caterpillars?
3. Which stage of caterpillars do they prefer?
4. How long does it take to lay an egg in each caterpillar?
5. During rearing, are all caterpillars parasitised? (recognized by a dead caterpillar with a hole on its side - for *Cotesia plutellae*)
6. If not, which stage is preferred? Why?
7. Are other kinds of caterpillars attacked? Why?

8. How many days take place/lapse attack by parasitoid and formation of parasitoid cocoon?
9. How many parasitoids emerge from one caterpillar?

**Method II:**

**Emergence of parasitoid from cocoons and hyperparasitism**

Collect parasitoid cocoons from the field and keep each cocoon separately in a clear plastic tube. Close the tube with cotton wool or mosquito netting. Observe what comes out and when. Observe for differences in male and female. Also observe for differences in size, colour and structure.

**Discussions:**

1. How many parasitoids emerge from each parasitoid cocoon?
2. After looking at the results of emergence of several cocoons, do all the insects look alike?
3. Which part of the cocoon will the parasitoid emerge? - middle of cocoon, end of cocoon?

**Method III:**

**Food requirement of parasitoids**

From newly emerged parasitoids, study five parasitoids without food using a clear plastic container. Record when they die and also record if these are males or females. For another five new parasitoids, provide honey solution (50% honey and 50% water) and record when these parasitoids die. A similar study can be done using water as food.

**Discussions:**

1. How long will a parasitoid survive without food?
2. How long will a parasitoid survive with honey solution?
3. How long will a parasitoid survive with only water?
4. Discuss the role of food in the survival of the parasitoid.
5. Where does the parasitoid get its food in the environment?

**Method IV:**

**Effects of residual insecticides on parasitoids**

Collect three pieces of leaves from a cabbage plant (free of insecticides). Spray one piece with one kind of insecticide such as pyrethroid, another with another kind of insecticide such as carbamates and the third with water. One of these pieces of leaves is then kept inside a clear plastic container and covered with mosquito net or organdie material. Two parasitoids are introduced inside each container and observations made at three minutes, five minutes, ten minutes and 15 minutes after exposure. Record if the parasitoids are still alive.

**Discussions:**

1. Are the parasitoids still alive in each treatment after 15 minutes?
2. If the parasitoids are not alive, why?
3. What does this study show?

## **CAGE EXCLUSION OF NATURAL ENEMIES**

### ***Introduction***

The effect of pesticides on natural enemies, i.e., reduction of natural enemies can be shown using exclusion cages. This study will demonstrate what happens when there are no natural enemies to check the increase in population of *Plutella*. The procedure used in this study can also be used to study other insects.

### **Methods:**

- Prepare twenty 50x50x70 cm nylon mesh cages, supported by four bamboo sticks, to cover individual cabbage plants.
- Select and label 20 plants (never use sticks as label, because this may stimulate predation by birds that use the sticks to sit and search for food).
- Randomly assign the plants as ten exclusion or ten control plants.
- Manually clear ('wash') the plants of any *Plutella* stages (eggs, larvae, pupae).
- To obtain eggs for inoculation of the plants, put 20-30 *Plutella* adults in each of 2-3 oviposition cages covering individual cabbage plants that had been manually cleared of eggs before caging.
- After 24 hours carefully observe all parts of the oviposition plants and cut out 3-6 cm<sup>2</sup> pieces of leaf containing 1-4 eggs of *Plutella*.
- Inoculate the target plants with a constant number of newly laid eggs (20) by stapling the leaf pieces bearing the eggs (from the oviposition cages) to the target plants (attach to underside of the leaves).
- If insufficient eggs are found on the first day to inoculate all the cages, start part of the cages on the first day (both treatments should be equally represented), and continue checking the oviposition cages for newly laid eggs for the other cages at consecutive days.
- In exclusion cages, remove all arthropods from the plant and the soil, and bury the nylon mesh carefully into the soil to prevent access of any predators (ants may gain access through small crevices in the soil).
- For the control treatment, use open cages (i.e. cages with the lower margin lifted about 15 cm from the ground) to allow free access of predators and parasites, while the nylon provides a similar degree of shading as in the exclusion cages.
- After 14 days, record larval and pupal densities per plant and evaluate the difference between the treatments.
- Conduct this trial three times during the season: one month after planting, mid-season and two weeks before harvest.
- At harvest, record the weights of each of the twenty plants.





# Insect Zoos for Tomato



## **PARASITISM OF LEAFMINERS**

### **Objective:**

Observe the parasitism levels of leafminers on tomato

### **Materials:**

IPM tomato field

FP tomato field

20 vials

Tissue paper

Honey

### **Method:**

Collect ten leaves with leaf miners from the IPM tomato field. (Note: To check for presence of leaf miners, hold leaves up against the light for viewing.) Transfer the leaves to vials with tissue paper inside (one leaf per vial). Label the vials with the date of collection, i.e., "IPM field" and the group name. Follow the same procedure for the FP field and label the vials with "FP field". Keep vials in a cool, shaded place. Upon emergence, feed parasites with honey solution to keep them alive for later release in the field.

### **Observations:**

Daily check the vials for emergence of adult leaf miners or parasites. Record the date of emergence and the number of leaf miners and/or parasites from the "IPM field" and the "FP field".

### **Discussions:**

1. Were there any parasites? Was there any difference in numbers of parasites which emerged from leaves from IPM and FP fields?
2. What is the effect of parasites on the leaf miner population?
3. What was the effect of pesticides on the level of parasitism?
4. How can the level of parasitism be increased?

*Bacillus*  
*thuringiensis*



## ASSESSMENT OF VIABILITY OF BT

### **Introduction**

Vegetable caterpillar pests have become resistant to a wide range of chemical insecticides. From different research studies around the world, Bt has been shown to effectively control caterpillar pests. However, since it is a sensitive biological agent, it is subject to rapid breakdown and loses its killing power. Use of Bt is part of an IPM programme that works with other natural enemies to control vegetable pests. Chemical insecticides do not do this. Therefore, this exercise is to discover the toxicity of Bt using living organisms as well as to determine if the Bt bought from the local shop is still useful for application in the field. After this exercise, the farmer/trainer will be able to answer the common question: Did I buy a good Bt and will it be effective against the caterpillar pest in my field?

Information from the World Health Organization (WHO) and the British Crop Protection Council indicates that the safety precautions when using Bt are much less than those for chemical insecticides. However, depending on the product formulation and the use pattern, it is advisable for users to observe the precautions indicated on the product label. Unlike chemical insecticides Bt products are considered non-toxic to humans, with no reports of allergic reactions or other health problems from users. Bt products do not require a pre-harvest interval.

### **Materials: (for each group)**

One unsprayed cabbage/tomato or French bean plant  
Two camel or fine hair brushes  
One pair of scissors  
One pair of forceps  
Ten plastic cups with plastic/organdie sheets used to cover the cup with rubber bands  
One packet of Bt bought from a local shop (use a different brand of BT for each group)  
(One syringe or glass pipette with calibrations to measure Bt, if using suspension)  
One litre of clean water  
One long wooden stirrer  
16 or more caterpillar larvae - preferably small ones  
One roll of tissue paper  
Plastic or rubber gloves

### **Method:**

1. Each group should fill two plastic cups with water. One cup will be used for the "Bt" treatment and one for the control (water). Label the cups according to the treatment, i.e., "Bt" and "Water".
2. Participants should carefully read the instructions on how to use the product printed on the label. Following the recommended dose (This differs from product to product!), participants should prepare the "Bt" solution. Trainers should call attention of participants to the correct dosage and appropriateness of mixing procedures – whether the Bt product is in powder or suspension form!
3. Also pay attention to how participants calibrate Bt to use in one liter of water. (Note: If using Bt suspension, make sure to shake the bottle thoroughly to disperse the solution evenly. Choose a syringe with a needle hole big enough to take up the suspension. If using a pipette, take up more than the volume required and release the excess back into the suspension bottle to get the exact quantity. Never use the mouth to suck the suspension into the pipette!)
4. Use a disposable long stirrer for each kind of product that will be used to prepare the solution and properly dispose of the stirrer.
5. All groups collect fresh inner leaves from the unsprayed cabbage/tomato or French bean plant. Cut the leaves into sections of 5 x 5 cm.

6. Members of the group who will set up the treatments should handle leaf sections with forceps. Dip one leaf section into the "Bt" cup and continue for three other sections. Similarly, dip four leaf sections into "Water" cup.
7. After removing the leaf sections from the solution, place one in each cup and label according to the treatment used. There should be four sections treated with "Bt" and four more with "Water".
8. Each cup should be lined with tissue paper. The leaf sections should be allowed to dry in a cool, shady place.
9. After the leaf sections are fairly dry, using the brush, transfer two caterpillars onto each of the leaf sections. Avoid damaging the caterpillars. Quicker results are obtained if smaller caterpillars are used. Do not use too many caterpillars per leaf section as they may be cannibalistic.
10. Each cup should be covered with either the plastic or organdie sheet held securely with rubber bands.
11. Groups daily take observations (see details below) and replace leaf sections until the completion of the experiment.
12. Remember: Dispose properly of empty Bt packets to prevent pollution of the environment. If you need to store unused Bt products, keep them in a cool, dark, dry place to prevent its breakdown. Wash hands thoroughly with soap and water after doing the exercise.

**Observations:**

All groups check the cups after 12 hours, 24 hours, 48 hours, and 72 hours. Record observations on the table suggested below taking note of the leaf damage, frass production (droppings of caterpillars), and the state of the larvae. Usually, obvious differences can be seen within 1.5 day.

**Discussions:**

1. What happened to the larvae in the two treatments?
2. Is there any difference in the amount of frass produced by the caterpillars? If yes, why so?
3. Why did we line the cup with tissue paper?
4. Why did we place the cups in the shade?
5. Why did we include a comparison with water?

*Bacillus thuringiensis*

Items	TREATMENT	Bt A			Bt B			Bt C			Bt D			Control (water)		
		REPLICATION			REPLICATION			REPLICATION			REPLICATION			REPLICATION		
		HOURS			HOURS			HOURS			HOURS			HOURS		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Leaf damage	12															
	24															
	48															
	72															
Frass production	12															
	24															
	48															
	72															
State of larvae	12															
	24															
	48															
	72															
Total	12															
	24															
	48															
	72															

**SCORING SYSTEM**

**LEAF DAMAGE**

- 1: low**
- 2: moderate**
- 3: high**

**Frass production**

- 1: none**
- 2: little**
- 3: much**

**State of larvae**

- 1: dead**
- 2: moribound**
- 3: active**



## INHIBITION OF LARVAL FEEDING BY BT

### ***Introduction***

This study will show how Bt inhibits larval feeding. Many farmers spray Bt without seeing immediate kill of the target insect. This is because Bt acts slower than conventional chemical insecticides but no less effective. Before actual death occurs, feeding by larvae stops. This often causes farmers to think that Bt is not effective. However, the benefits of Bt (conservation of parasitoids and predators, overall minimal health risk to farmers and consumers, minimal adverse effects on the environment) far outweighs the speed of killing caterpillars using chemical insecticides. Moreover, resistance in the target caterpillars to chemical insecticides have rendered them less effective than Bt. After this exercise, the farmer/trainer should be able to understand how Bt kills the target caterpillar and realize that Bt makes the pest stop feeding hence, there is less damage caused.

### **Materials: (for each group)**

One unsprayed cabbage/tomato or French bean plant  
Two camel of fine hair brushes  
One pair of scissors  
One pair of forceps  
Ten plastic cups with plastic/organdie sheets and rubber bands  
One roll of tissue paper  
One packet of Bt  
(One syringe or glass pipette with calibrations to measure Bt, if using suspension)  
Two litres of clean water  
One plastic pail/container  
One long wooden stirrer  
One set of paper and pencil  
Plastic or rubber gloves

### **Method:**

1. Each group should fill two plastic cups with water. One cup will be used for the "Bt" treatment and one for the control (water). Label the cups according to the treatment, i.e., "Bt" and "Water".
2. Participants should carefully read the instructions on how to use the product printed on the label. Following the recommended dose (This differs from product to product!), participants should prepare the "Bt" solution. Trainers should call attention of participants to the correct dosage and appropriateness of mixing procedures – whether the Bt product is in powder or suspension form!
3. Also pay attention to how participants calibrate Bt to use in one liter of water. (Note: If using Bt suspension, make sure to shake the bottle thoroughly to disperse the solution evenly. Choose a syringe with a needle hole big enough to take up the suspension. If using a pipette, take up more than the volume required and release the excess back into the suspension bottle to get the exact quantity. Never use the mouth to suck the suspension into the pipette!)
4. Use a long disposable stirrer for each kind of product that will be used to prepare the solution and properly dispose of the stirrer.
5. All groups collect fresh leaves from the upper part of the cabbage, tomato or French bean plant. Cut leaves into 5 x 5 cm sections.
6. Members of the group who will set up the treatments should handle leaf sections with forceps. Dip four leaf sections into the Bt solution. Place one section per cup lined with tissue paper and labelled "Bt". Using another four leaf sections, dip into the cup with only water and place these into separate cups labelled "Water". Let the leaf sections dry in a cool, shady place.
7. After the leaf sections are fairly dry, using the brush, transfer two caterpillars onto each of the leaf sections. Avoid damaging the caterpillars. Quicker results are obtained if smaller caterpillars are used. Avoid damaging the caterpillars. Do not use too many caterpillars per leaf section as they may be cannibalistic.

## *Bacillus thuringiensis*

8. Each cup should be covered with either the plastic or organdie sheet held securely with rubber bands.
9. Groups daily take observations (see details below) and replace leaf sections until the completion of the experiment.
10. Remember: Dispose properly of empty Bt packets to prevent pollution of the environment. If you need to store unused Bt products, keep them in a cool, dark, dry place to prevent its breakdown. Wash hands thoroughly with soap and water after doing the exercise.

### **Observations:**

Groups should check the cups after every 12 hours and continue up to three days. Using paper and pencil, trace the leaf area of the leaf section from both “Bt” cup and “Water” treatments. Compare the leaf tracings. Observe the amount of faecal matter in both treatments. Usually, obvious differences can be seen within 1.5 day.

### **Discussions:**

1. Were there any differences in feeding between Bt-treated and water-treated leaf sections?
2. When did these differences occur?
3. Were there any differences in amount of faecal matter produced?
4. What do these differences indicate?
5. Did the larvae stop feeding? What could have caused this to happen?

## **SENSITIVITY OF BT TO SUNLIGHT**

### ***Introduction***

This study will show how sunlight breaks Bt down. Since Bt is a biological agent, it is sensitive to sunlight. In bright sunlight, it loses its effectiveness and strength to kill caterpillars. After this study, you should be able to understand the effect of sunlight on the effectiveness of Bt and to make appropriate decisions on how to apply Bt observing appropriate precautionary measures.

### **Materials: (for each group)**

Two rows of cabbage, tomato or French bean plants (about 15-30 days after planting)

One potted cabbage, tomato or French bean plant (about 15-30 days after planting)

16 DBM or similar caterpillars (small and of similar size)

One hand sprayer (1 litre size will suffice)

One packet of Bt

(One syringe or glass pipette with calibrations to measure Bt, if using suspension)

Three camel or fine hair brushes

One pair of scissors

One pair of forceps

One pail of clean water

One long wooden stirrer

12 plastic cups with plastic/organdie sheets and rubber bands

Plastic or rubber gloves

### **Method:**

1. Participants prepare the hand sprayers before setting up the exercise. If the sprayers have been used before, wash them thoroughly with detergent. Use gloves when washing the sprayers. Check to see if the sprayers are working properly by pumping and spraying water. This will also clean the hose of the sprayer. If necessary, use water or a soft probe like a weed stem to clean the hose and clear the holes of the sprayer.
2. Set up the exercise towards midday. Participants should carefully read the instructions on how to use the product printed on the label. Following the recommended dose (This differs from product to product!), participants should prepare the "Bt" solution in plastic pails. Trainers should call attention of participants to the correct dosage and appropriateness of mixing procedures – whether the Bt product is in powder or suspension form!
3. Also pay attention to how participants calibrate Bt to use in one pail of water. (Note: If using Bt suspension, make sure to shake the bottle thoroughly to disperse the solution evenly. Choose a syringe with a needle hole big enough to take up the suspension. If using a pipette, take up more than the volume required and release the excess back into the suspension bottle to get the exact quantity. Never use the mouth to suck the suspension into the pipette!)
4. Use a long disposable stirrer for each kind of product that will be used to prepare the solution and properly dispose of the stirrer.
5. At midday, groups spray one row (about four plants) of cabbage, tomato or French bean plants. Spray Bt on the upperside of leaves moving from the top towards the bottom portion of the plant. Then spray Bt on the underside of leaves moving from the bottom towards the top portion of the plant. Make sure that both sides of the leaves are drenched with the solution. Spray following the direction of the wind.
6. In the evening, just before sunset spray another row of plants (another four plants). Follow the same technique for spraying Bt done during the midday spray session.
7. For both midday and evening spray sessions, members of the group who will set up the treatments should wash hands thoroughly with soap and water, and change clothes after spraying.
8. An hour after the last spray, groups collect leaves from both rows and cut out leaf sections of 5 x 5 cm and ensure that these are labelled. Similar sections are prepared from a potted plant free of insecticides.

## *Bacillus thuringiensis*

9. Each of the leaf section is kept in a plastic cup lined with tissue paper and the cups labelled as "Bt-sunlight", "Bt-no sun" and "No Bt".
10. Caterpillars collected from the field (preferably smaller ones as these react faster than older caterpillars) are used for the study. Two caterpillars are dropped onto each leaf section and the cups stored in a cool, shady place.
11. Remember: Dispose properly of empty Bt packets to prevent pollution of the environment. If you need to store unused Bt products, keep them in a cool, dark, dry place to prevent its breakdown. Wash hands thoroughly with soap and water after doing the exercise.

### **Observations:**

Groups should check the cups after every 12 hours and continue up to three days. Observe signs of feeding. Using paper and pencil, trace the leaf area of the leaf section in all treatments. Compare the leaf tracings noting the size of holes. Observe the amount of faecal matter produced in all treatments. Record number of living larvae. Usually, obvious differences can be seen within 1.5 day.

***NOTE: This study may be repeated at two-day intervals to determine the effectiveness of Bt on cabbages, tomato and French beans in the field.***

### **Discussions:**

1. Did the larvae feed on the leaves?
2. Did any of the larvae die? In which treatment?
3. What was the effect of sunlight on Bt?
4. Why should we repeat the study?
5. When is the best time of the day to apply Bt?

## EFFECT OF BT ON PREDATORS AND PARASITOIDS

### **Introduction**

This study will attempt to show the impact of spraying Bt on both predators (insects or spiders that eat other insects, particularly pests) and parasitoid (insects that lay eggs in or on its host so that the host provides food for the young stages of the parasitoid). A danger in using chemical insecticides is that it kills friendly insects that help farmers control pest organisms. As Bt is applied as a spray, this exercise will help farmers to discover the impact of Bt on these beneficial insects. After this activity, you should be able to relate the action of Bt on a natural enemy and better appreciate the role of Bt in an IPM programme.

### **Materials: (for each group)**

Two cabbage, tomato or French bean plants (15-30 days after planting)  
Two hand sprayers (1 litre)  
One pail of clean water  
One packet of Bt  
(One syringe or glass pipette with calibrations to measure Bt, if using suspension)  
One pair of scissors  
One pair of forceps  
One long wooden stirrer  
Four large plastic cups with organdie cloth sheet and rubber bands  
Two camel or fine hair brushes  
Ten parasitoid cocoons (e.g. *Cotesia plutellae*)  
Ten common predators from the field  
Ten clear plastic film containers  
One small bottle of honey  
One roll of cotton wool  
One roll of tissue paper  
Plastic or rubber gloves

### **Method:**

1. Groups collect parasitoid cocoons (e.g. *Cotesia plutellae*) from the field. Place one each of the parasitoid cocoons into the film containers. Store the containers in a cool shaded place until adult parasitoids emerge. Feed the adult parasitoids with a diluted honey solution (on small pieces of moist cotton wool).
2. Participants prepare the hand sprayers before setting up the exercise. If the sprayers have been used before, wash them thoroughly with detergent. Use gloves when washing the sprayers. Check to see if the sprayers are working properly by pumping and spraying water. This will also clean the hose of the sprayer. If necessary, use water or a soft probe like a weed stem to clean the hose and clear the holes of the sprayer.
3. When there are sufficient adult parasitoids, set up the treatments. Participants should carefully read the instructions on how to use the product printed on the label. Following the recommended dose (This differs from product to product!), participants should prepare the "Bt" solution in plastic pails. Trainers should call attention of participants to the correct dosage and appropriateness of mixing procedures – whether the Bt product is in powder or suspension form!
4. Also pay attention to how participants calibrate Bt to use in one pail of water. (Note: If using Bt suspension, make sure to shake the bottle thoroughly to disperse the solution evenly. Choose a syringe with a needle hole big enough to take up the suspension. If using a pipette, take up more than the volume required and release the excess back into the suspension bottle to get the exact quantity. Never use the mouth to suck the suspension into the pipette!)
5. The members of the group should use a long disposable stirrer for each kind of product that will be used to prepare the solution and properly dispose of the stirrer.
6. Members of the group who will set up the treatments should spray Bt on the upperside of leaves moving from the top towards the bottom portion of the plant. Then spray Bt on the

## *Bacillus thuringiensis*

underside of leaves moving from the bottom towards the top portion of the plant. Make sure that both sides of the leaves are drenched with the solution. Spray following the direction of the wind. Wash hands thoroughly with soap and water, and change clothes after spraying.

7. Allow an hour to dry.
8. Groups collect leaves from the upper part of the plant and cut out leaf sections of 5 x 5 cm size and place these into the large plastic cups with cover. Label each cup.
9. Leaves from an unsprayed plant should be collected and similarly prepared. Place a solution of diluted honey in each plastic cup and introduce a parasitoid into each of the cups and secure the cover with rubber bands.
10. Groups should keep the cups in a cool shaded place and observe every day. Record the number of dead parasitoids in each treatment.
11. A similar study is conducted with field collected predators (e.g. spiders, syrphid larvae, etc.). However, with predators there is no need for honey solution but appropriate food must be provided.
12. Remember: Dispose properly of empty Bt packets to prevent pollution of the environment. If you need to store unused Bt products, keep them in a cool, dark, dry place to prevent its breakdown. Wash hands thoroughly with soap and water after doing the exercise.

### **Discussions:**

1. Why did we put diluted honey solution in cups with parasitoids?
2. Was there any dead parasitoid or predator in the cups? Why?
3. Would you think that Bt kills parasitoids and predators?

# **Nuclear Polyhedrosis Virus**





## **IDENTIFICATION OF VIRUS-INFECTED INSECTS (CLASSROOM EXERCISE)**

### ***Introduction***

Today, natural viruses are used to manage insect pests and to reduce the use of chemical insecticides that are harmful for man and the environment. Natural viruses as a biocontrol agent have become a component of the IPM system. In Vietnam, the Biological Control Research Center, National Institute of Plant Protection (NIPP) has done some work on methods of production and application of viruses in controlling insect pests. The methods have been simplified to allow trainers and farmers to work with the agent with minimum support from the research institute and trainers. This exercise will provide trainers and farmers first hand experience in the classroom in observing and comparing symptoms of virus-infected insect pests and insects which died because of other reasons, e.g., pesticides, etc.

***Objective:*** Describe symptoms of virus-infected insects

### ***Materials:***

Specimen, i.e., virus-infected insects from the laboratory (enough material for all five small groups)  
Paper and markers

### ***Method:***

Use this exercise at the start of the season, when infected insects or insects which have died because of virus are not yet readily seen in the field. Ask each small group to recall their experiences on seeing dead or infected insects in the field. Each group should then draw their observations on big paper for presentation.

After all groups have presented their outputs, introduce the specimens of virus-infected insects from the laboratory. Ask each group to describe symptoms of the specimens from the laboratory.

(Note: Insects infected by viruses become weak and activity is slowed down; the body color is changed; the cuticle becomes fragile and ruptures easily when touched, releasing the body content which has become liquefied. Dead larvae may be found hanging from or lying on leaf or plant surfaces with no filamentous structure on the cuticle.)

### ***Questions:***

1. Based on experience, describe different appearance or symptoms exhibited by dead insects in the field? Describe the field conditions at the time the observations were made. Discuss about host populations, insecticide use, weather etc.
2. Describe appearance and characteristics of specimen from the laboratory. Have insects with such appearance and characteristics been observed in the field? What could have caused such symptoms? What does this mean for management of insect pests?

# IDENTIFICATION OF VIRUS-INFECTED INSECTS (FIELD EXERCISE)

## ***Introduction***

Today, natural viruses are used to manage insect pests and to reduce the use of chemical insecticides harmful for man and the environment. Natural viruses as a biocontrol agent have become a component of the IPM system. The Biological Control Research Center, National Institute of Plant Protection (NIPP) has done some work on methods of production and application of viruses in controlling insect pests. The methods have been simplified to allow trainers and farmers to work with the agent with minimum support from the research institute and trainers. This exercise will provide trainers and farmers first hand experience in the field in observing and comparing symptoms of virus-infected insect pests and insects which died because of other reasons, e.g., pesticides, etc.

***Objective:*** Describe symptoms of virus-infected insects

## ***Materials:***

Specimens collected from fields  
Paper and markers

## ***Method:***

Do this activity once viruses are seen to spread in the FFS area. (Initially, inoculum may be introduced from the laboratory.) Ask each group of five to recall the classroom exercise done earlier, i.e., the discussion re: experiences on seeing dead or infected insects in the field and introduction of specimen from the laboratory.

Go to the field. Ask each subgroup to collect all dead insects that they see in the field.

In the classroom, groups should sort the dead insects based on appearance and symptoms exhibited. Then, using the group's drawing from the earlier exercise, groups present their field observations, i.e., their collection of insects from the field.

(Note: Insects infected by viruses become weak and activity is slowed down; the body color is changed; the cuticle becomes fragile and ruptures easily when touched, releasing the body content which has become liquefied. Dead larvae may be found hanging from or lying on leaf or plant surfaces with no filamentous structure on the cuticle.)

## ***Questions:***

1. Based on experience, describe different appearance or symptoms exhibited by dead insects in the field? Describe the field conditions at the time the observations were made. Discuss about host populations, insecticide use, weather etc.
2. Were there insects with the same appearance and characteristics as the specimen from the laboratory? What does this mean for management of insect pests?

## **METHOD OF PRODUCTION AND APPLICATION OF VIRUS IN MANAGING INSECT PESTS ON VEGETABLES**

### ***Introduction***

In the natural setting, insect pests are infected by many microorganisms like viruses, bacteria, fungi, protozoa, etc. In a number of cases, viruses have been recognized as a biocontrol agent in checking insect pest population. Every year, during months when the climatic condition is hot and sunny and the humidity is high, several insect pests on cotton, e.g., leaf roller (*Silepta derogata*) and armyworm (*Spodoptera litura*) are infected by viruses. This helps reduce the caterpillar population.

Today, natural viruses are used to manage insect pests and to reduce the use of chemical insecticides which are harmful for man and the environment. Natural viruses as a biocontrol agent have become a component of the IPM system. In Vietnam, the Biological Control Research Center, National Institute of Plant Protection has done some work on methods of production and application of viruses in controlling insect pests. The methods have been simplified to allow trainers and farmers to work with the agent with minimum support from the research institute and trainers.

***Objective:*** Experience producing virus for use in testing whether they infect other insects

### ***Materials:***

Small rectangular plastic containers/penicillin vials and wood rack (depending on species of larvae)  
Muslin cloth for filtering virus solutions  
Paper to cover the plastic containers  
Mortar and pestle  
Glass bottle with cover 0.5 liter capacity  
Pincers  
Dark plastic can or glass bottle to keep virus suspension  
A large number of small larvae  
Natural diet: cotton leaves, etc.  
Jaggery or vegetable oil  
Boiled water (boil for 20-30 minutes and let it cool)

### ***Method:***

#### **I. Producing the virus solution**

There are two procedures for producing virus solutions. Virus products are prepared using infected larvae collected from the field or larvae infected in the laboratory.

#### **Procedure A: Using infected larvae collected from the field**

1. Look out for the time of appearance and the development of disease in natural conditions. As soon as they are observed, collect dead larvae from the field and store them in a covered glass bottle to produce the virus products.
2. Putrefy for two – three days.
3. Macerate in mortar.
4. Add a little boiled water at a time, stir and filter through muslin cloth to discard tissue debris. Repeat this step until the extract obtained is clear.
5. To extract from 500 – 1000 large-sized larvae, add one liter boiled water. Do not use unboiled water because it can ruin products.
6. After filtering, store the mixture in colored bottles or dark cans. Store in a cool dark place.
7. Add 0.5% jaggery before using to spray in the evening.

#### **Procedure B-1: Using small-sized larvae infected in the laboratory**

1. Mass rearing of insects  
A large number of larvae is needed to produce viruses. Rear the larvae in clean plastic containers with natural diet, i.e., cotton leaves, etc. Replace leaves every day. Leaves should be fresh and not too old. Cover the containers with cloth or paper to keep larvae from escaping. When the larvae have grown up to 10 - 15 mm long, they can be infected with the inoculum.
2. Preparing the inoculum

To create an initial disease source or inoculum, collect larvae from the field exhibiting symptoms of virus infection. Use one (1) rather big larva (about 30mm long) to 100ml clean boiled water. With the mortar and pestle, grind the diseased dead larvae. Add a little clean boiled water at a time, stir and filter through muslin cloth to discard tissue debris. Repeat this step until the extract obtained is clear. Do not use unboiled water because it can ruin products. Soak food plant leaves in the liquid, air dry them, and then feed them to the healthy larvae in the containers.

3. Preparation of virus product/solution  
Observe the larvae every day. Three to four days after the symptoms of disease have appeared and larvae begin dying, use pincers to remove all the dead larvae and transfer them into a glass bottle with lid/cover. Discard all the dead larvae not infected by virus.
4. Putrefy for 2 - 3 days.
5. Macerate in mortar. Add a little clean boiled water at a time, stir and filter through muslin cloth to discard tissue debris. Repeat this step until the extract obtained is clear.
6. To extract from 500 – 1000 large-sized larvae, add one liter boiled water. Do not use unboiled water because it can ruin products.
7. After filtering, store the mixture in colored bottles or dark cans. Store in a cool dark place.

Procedure B-2: Using medium-sized larvae infected in the laboratory

1. Collect medium-sized, healthy larvae from the field.
2. Inoculate larvae by feeding virus treated leaves for two days. To prepare the leaves, soak them in the inoculum and air dry before feeding to the healthy larvae. (For details, refer to Procedure B-2 step 2.)
3. Infected larvae will turn white and die in seven days. Collect diseased larvae in clean boiled water.
4. Putrefy for 2 - 3 days.
5. Macerate in mortar. Add a little clean water at a time, stir and filter through muslin cloth to discard tissue debris. Repeat this step until the extract obtained is clear.
6. To extract from 500 – 1000 large-sized larvae, add one liter clean boiled water. Do not use unboiled water because it can ruin products.
7. After filtering, store products in colored bottles or dark cans. Store in a cool, dark place.

## II. Applying the virus solution

Larvae in the final instar are resistant to the virus. However, the virus will efficiently control earlier instar larvae if applied as follows:

1. Use a dosage of extract from 500 – 1000 large-sized, diseased larvae to 600 - 800 liters of water per hectare.
2. Add 0.5% jaggery or vegetable oil.
3. Spray 2-3 times at intervals of 7-10 days.
4. Spray in the evening hours to prevent destruction of the virus by the UV fraction of sunlight.

Avoid:

1. Brackish water for storing as well as spraying the virus
2. Grown up caterpillars for virus inoculation
3. Spraying in hot, sunny conditions.

### ***Questions:***

1. How are larvae infected by the virus?
2. Were viruses found in the FFS fields? Describe conditions in the field at the time when the viruses were observed. What factors influence whether or not viruses can spread? Discuss about host populations, insecticide use, weather etc.
3. What action should the farmer group take if it wants more farmers in the area to make use of viruses? How can this be done?

## **SPREAD OF VIRUSES TO SURROUNDING FIELDS**

### ***Introduction***

In the ToF or FFS field, viruses (NPV) have been sprayed and groups have made weekly observations in the study area. If you start finding diseased/deceased insects (insects that are sick or have died because of virus) regularly in the ToF or FFS area, it will be good to find out whether the viruses have also spread to surrounding fields. Carry this activity out as a special topic, once you start to see the virus spread in the ToF or FFS area. It can also be repeated several times during the season to determine the extent of spread of the virus.

***Objective:*** Find out if the viruses can spread to other fields surrounding the ToF or FFS area

### ***Materials:***

Fields surrounding the ToF or FFS area  
Paper and markers

### ***Method:***

Ask each small group of five to select three fields close to the ToF or FFS area. Each group will observe 30 plants in each field following the same methods as in the ToF or FFS area:

*Spodoptera:*            number of larvae per plant  
                              number of pupae per plant  
                              if possible, the number of egg mass per plant (though it is quite difficult to see) If  
                              too difficult, do not observe.  
                              number of diseased/deceased larvae (by virus infection)

*Heliothis:*            number of larvae per plant  
                              number of pupae per plant  
                              if possible, also the number of eggs per plant (though it is quite difficult to see) If  
                              too difficult, do not observe.  
                              number of diseased/deceased larvae (by virus infection)

After observations by each small group in the field, ask each group to summarize the following information:

number of larvae of *Spodoptera litura* per plant  
number of larvae of *Heliothis* per plant  
number of virus diseased/deceased larvae of *Spodoptera litura* per plant  
number of virus diseased/deceased larvae of *Heliothis* per plant  
 $\% \text{ of infection by NPV} = \frac{\# \text{ of virus diseased or deceased larvae}}{\text{Total number of larvae}}$

(Note: The total number of larvae = healthy larvae + virus diseased or deceased larvae + diseased or deceased larvae due to other factors)

(If parasites were observed, groups should also summarize % of parasitized eggs or larvae.)

Ask each group also to record the stage of crop development.

Make one map indicating the fields each group observed. Write down on the map the number of insect pests and how many of these are sick or died due to virus and the % of infection in each field.

### ***Questions:***

1. Were viruses found in the surrounding fields?
2. What factors influence whether or not viruses can spread? Discuss about host species, host populations, insecticide use, weather etc.
3. If activity was repeated at a later stage: How does the situation of surrounding fields compare with the previous observation? Did the number of virus-infected insects increase or decrease?
4. What action should the farmer group take if it wants more farmers in the area to make use of viruses? How can this be done?

## ASSESSMENT OF VIABILITY OF NPV

This exercise will use living organisms to determine if NPV has maintained its toxicity in storage or whether the NPV purchased from a store is still useful for application in the field.

### **Introduction:**

Vegetable caterpillar pests such as *Spodoptera* have become resistant to a wide range of chemical insecticides. From different research studies around the world, NPV has been shown to effectively control *Spodoptera* and other caterpillar pests. However, since it is a sensitive biological agent, it is subject to rapid breakdown and loses its killing power. Use of NPV is part of an IPM programme which works with other natural enemies to control cotton pests. Chemical insecticides do not do this. Therefore, this exercise is to discover the toxicity of NPV as well as to determine if the NPV bought from the local shop is still useful. After this exercise, the farmer/trainer will be able to answer the common question: Did I buy a good NPV and will it be effective against the caterpillar pest in my field?

### **Materials:**

- 1 unsprayed cabbage plant
- 2 camel or fine hair brushes
- 1 pair of scissors
- 10 plastic cups with plastic/organdie sheets used to cover the cup with rubber bands
- 1 packet of NPV bought from a local shop (use a different brand of NPV for each group)
- 1 litre of clean water
- 16 or more bollworm/*Spodoptera* larvae - preferably small ones
- 1 roll of tissue paper

### **Method:**

Fill 2 plastic cups with water. Mix 1/4 teaspoon NPV into water in one cup. Label the cup "NPV" and the other cup "Water". Collect fresh leaves from the unsprayed cabbage plant. Cut the leaves into sections of 1" diameter. Dip one leaf section into the "NPV" cup and continue for three other sections. Similarly, dip four leaf sections into "Water" cup. After removing the leaf sections from the solution, place one in each cup and label according to the treatment used. There should be four sections treated with "NPV" and four more with "Water". Each cup should be lined with tissue paper. The leaf sections should be allowed to dry in a cool, shaded place.

After the leaf sections are fairly dry, using the brush, transfer two caterpillars into each of the leaf sections. Avoid damaging the caterpillars. Quicker results are obtained if smaller caterpillars are used. Do not use too many caterpillars per leaf section as they may be cannibalistic. Each cup should be covered with either the plastic or organdie sheet held securely with rubber bands.

### **Observations:**

Check the cups every 10-12 hours and observe for frass (droppings of caterpillars) and larval death. Usually, obvious differences can be seen within 1.5 day.

### **Questions:**

1. What happened to the larvae in the two treatments?
2. Is there any difference in the amount of frass produced by the caterpillars? If yes, why so?
3. Why did we line the cup with tissue paper?
4. Why did we place the cups in the shade?
5. Why did we include a comparison with water?

## **INHIBITION OF LARVAL FEEDING BY NPV**

This study will show how NPV inhibits larval feeding. Many farmers spray NPV without seeing immediate kill of the target insect. This is because NPV acts slower than conventional chemical insecticides but no less effective. Before actual death occurs, feeding by larvae stopped. This often causes farmers to think that NPV is not effective. However, the benefits of NPV (conservation of parasitoids and predators, overall minimal health risk to farmers and consumers, minimal adverse effects on the environment) far outweighs the speed of killing caterpillars using chemical insecticides. Moreover, resistance in the target caterpillars to chemical insecticides have rendered them less effective than NPV. After this exercise, the farmer/trainer should be able to understand how NPV kills the target caterpillar and realize that NPV makes the pest stop feeding hence, there is less damage caused.

### ***Materials:***

- 1 unsprayed cabbage plant
- 2 camel or fine hair brushes
- 1 pair of scissors
- 10 plastic cups with plastic/organdie sheets and rubber bands
- 1 roll of tissue paper
- 1 packet of NPV
- 2 litres of clean water
- 1 plastic pail/container
- 1 long wooden stirrer
- 1 set of paper and pencil

### ***Method:***

Collect fresh leaves from the upper part of the cabbage plant. Cut leaves into 1" diameter sections. Using a pail or containers, pour a litre of water and mix the recommended dose of NPV on the label. Mix well using a long stirrer. Dip four leaf sections into the pail with NPV solution. Place one section per cup lined with tissue paper and label "NPV". Using another four leaf sections, dip into a cup with only water and place these into separate cups labeled "Water". The next morning, check for feeding and/or larval death. Replace the leaf sections (NPV treated ones in the "NPV" cup and water treated ones in "Water" cup). At noon, check again on feeding. Using paper and pencil, trace the area of the leaf section from the "NPV" cup and the "Water" cup. replace the leaves removed for drawing. Compare the leaf tracings from both "NPV" and "Water" cup. Observe the amount of faecal matter in both sets of treatments. Repeat the above observations in the late afternoon and continue to three days.

### ***Questions:***

1. Were there any differences in feeding between NPV treated and water treated leaf sections?
2. When did these differences occur?
3. Were there any differences in amount of faecal matter produced?
4. What do these differences indicate?
5. Comment on larval feeding activity.

## **SENSITIVITY OF NPV TO SUNLIGHT**

This study will show how sunlight breaks NPV down. Since NPV is a biological agent, it is sensitive to sunlight. In bright sunlight, it loses its effectiveness and strength to kill caterpillars. After this study, you should be able to appreciate the effect of sunlight on the effectiveness of NPV and to make appropriate decisions on how to apply NPV.

### ***Materials:***

- 2 rows of cabbage plants (about 15-30 days after planting)
- 1 potted cabbage plant (about 15-30 days after planting)
- 16 bollworm or similar caterpillars (small and of similar size)
- 1 hand sprayer (1 litre size will suffice)
- 1 packet of NPV
- 3 camel or fine hair brushes
- 1 pair of scissors
- 1 pail of clean water
- 12 plastic cups with plastic/organdie sheets and rubber bands

### ***Method:***

Mix NPV at recommended rate in a pail of water and spray one row of cabbage plants at midday. Use about four plants. In the evening, just before sunset spray another row of cabbage plants (another 4 plants). An hour after the last spray, collect leaves from both rows and cut out leaf sections of 1" diameter and ensure that these are labeled. Similar sections are prepared from a potted plant free of insecticides. Each of the leaf section is kept in a plastic cup lined with tissue paper and the cups labeled as "NPV-sunlight", "NPV-no sun" and "No NPV". Caterpillars collected from the field (preferably smaller ones as these react faster than older caterpillars) are used for the study. Two caterpillars are dropped onto each leaf section and the cups stored in a cool, shade place. Observe for signs of feeding (size of holes made in the leaf section as well as amount of faecal matter produced) as well as record number of living larvae. Continue the study for up to 3 days.

NOTE: This study may be repeated at two days interval to determine the effectiveness of NPV on vegetable crops in the field.

### ***Questions:***

1. Did the larvae feed on the leaves?
2. Did any of the larvae die? In which treatment?
3. What do you think was the effect of sunlight on NPV?
4. Why should we repeat the study?
5. When is the best time of the day to apply NPV?



## **EFFECT OF NPV ON PREDATORS AND PARASITOIDS**

This study will attempt to show the impact of spraying NPV on both predators (insects or spiders that eat other insects, particularly pests) and parasitoid (insects that lay eggs in or on its host so that the host provides food for the young stages of the parasitoid). A danger in using chemical insecticides is that it kills friendly insects that help farmers control pest organisms. As NPV is applied as a spray, this exercise will help farmers to discover the impact of NPV on these beneficial insects. After this activity, you should be able to relate the action of NPV on a natural enemy and better appreciate the role of NPV in an IPM programme.

### ***Materials:***

- 2 cabbage plants (15-30 days after planting)
- 2 hand sprayers (1 litre)
- 1 pail of clean water
- 1 packet of NPV
- 4 large plastic cups with organdie cloth sheet and rubber bands
- 2 camel or fine hair brushes
- 10 parasitoid cocoons
- 10 common predators from vegetable field
- 10 clear plastic film containers
- 1 small bottle of honey
- 1 roll of cotton wool
- 1 roll of tissue paper

### ***Method:***

From the parasitoid cocoons collected from the field, place one each into the film containers. Store the containers in a cool shaded place until adult parasitoids emerge. Feed the adult parasitoids with a diluted honey solution (on a moist cotton wool). When there are sufficient adult parasitoids, mix NPV at the recommended rate and spray a cabbage plant with it. Allow an hour to dry. Collect the leaves from the upper part of the plant and cut out leaf sections of 1" diameter size and place these into the large plastic cups with cover. Label each cup. Similarly, leaves from an unsprayed plant would be collected and similarly prepared. Place a solution of diluted honey in each plastic cup and introduce a parasitoid into each of the cups and secure the cover with rubber bands. Store the cups in a cool shaded place and observe every day. Record the number of dead parasitoids in each situation. A similar study is conducted with field collected predators (e.g. spiders, syrphid larvae etc.). With predators there is no need for honey solution.

### ***Questions:***

1. Why did we put a diluted honey solution in cups with parasitoids?
2. Was there any dead parasitoid or predator in the cups? Why?
3. Would you think that NPV kills parasitoids and predators?

# EFFECT OF FUNGICIDES ON THE VIABILITY OF NPV

## **Introduction**

We have seen how insect pests can be infected by microorganisms like viruses that are now recognized as a biological control agent in checking insect pest populations. We also know from experience that farmers still have problems managing crop diseases, and use fungicides to control disease. NPV is a sensitive biological agent. Since NPV is a causal organism for disease in insect pests and farmers use fungicides to control disease in the crop, there is a danger that fungicides may inhibit the action of NPV. This exercise will attempt to show the effect of fungicide sprays on the viability of NPV.

**Objective:** Explain the effect of fungicides on the action of NPV

## **Materials:**

### **Method A:**

20 plastic cups covered with plastic/muslin cloth and secured with rubber bands  
32 or more *Spodoptera* or 16 or more *Heliothis* larvae - preferably small ones

### **Method B:**

20 plastic cups covered with plastic/muslin cloth and secured with rubber bands  
32 or more *Spodoptera* or 16 or more *Heliothis* larvae - preferably small ones  
Four small hand sprayers (0.5 liter capacity)

### **For both methods:**

1 unsprayed cabbage plant  
2 camel or fine hair brushes  
1 pair of scissors  
NPV preparation  
Fungicide  
1 litre of clean water  
1 roll of tissue paper  
Labels  
Paper and pen

### **Method A: Using leaf sections**

1. Fill 4 plastic cups with water. Prepare solutions for 4 treatments:
  - Mix 1/4 teaspoon NPV into water in one cup and label the cup "NPV"
  - Mix fungicide based on recommended dose into water in one cup and label the cup "fungicide"
  - Mix 1/4 teaspoon NPV and fungicide based on recommended dose into water in one cup and label the cup "NPV + fungicide"
  - Keep one cup only with water, and label the cup "Control"
2. Collect fresh leaves from the unsprayed cabbage plant. Cut a total of sixteen leaf-sections, each section measuring 1" in diameter.
3. Dip four leaf sections into the "NPV" cup. Similarly, dip four leaf sections into the "Fungicide" cup. Do the same for the "NPV + fungicide" and the "Water" cups.
4. After removing the leaf sections from the solutions, allow them to dry in a cool, shaded place.
5. Line each cup with tissue paper.
6. When the leaf sections are fairly dry, place one section in each cup. Label cups according to the treatment used. There should be four cups for each treatment.
7. Using the brush, transfer two caterpillars onto each of the leaf sections. Avoid damaging the caterpillars.
8. To obtain quicker results use smaller caterpillars. If using *Heliothis*, use one caterpillar per leaf section, as they may be cannibalistic.
9. Cover each cup with the plastic/muslin cloth and secure with rubber bands.

**Method B: Spraying directly on insects**

1. Prepare four hand sprayers before the practical. If a sprayer has been used before, wash it thoroughly with detergent.
2. Prepare solutions according to the four treatments below. Put one solution each of the hand sprayers and correspondingly. The four preparations are:
  - “NPV”: Mix 1/4 teaspoon NPV with one cup of water
  - “Fungicide”: Mix fungicide with one cup of water based on recommended dose
  - “NPV + Fungicide”: Mix 1/4 teaspoon NPV and fungicide based on recommended dose with one cup of water
  - "Control": Put only water
3. Spray four pieces of muslin cloth with one of each treatment and air-dry the pieces of cloth.
4. Collect fresh leaves from the unsprayed cabbage plant. Cut a total of sixteen leaf-sections, each section measuring 1" in diameter.
5. Line each cup with tissue paper and place one leaf section in each.
6. Collect several caterpillars from the field. Avoid damaging the caterpillars. Quicker results are obtained if smaller caterpillars are used.
7. Using the brush, transfer two caterpillars onto each of the leaf sections. If using *Heliothis*, use one caterpillar per leaf section as they may be cannibalistic.
8. Cover each cup with the muslin cloth and secure with rubber bands.
9. Label cups according to the treatment used. There should be four cups for each treatment.
10. Check the cups every 10-12 hours and look for frass (droppings of caterpillars) and larval death. Usually, obvious differences can be seen within 3- 4 days.

**Questions:**

1. What happened to the larvae in the four treatments?
2. Is there any difference in the amount of frass produced by the caterpillars? If yes, why so?
3. How many days did it take to observe symptoms of disease on the caterpillars? Describe the symptoms and time of occurrence of disease on caterpillars in the different treatments. Do caterpillars in one treatment exhibit more symptoms than those in other treatments? Did they get sick sooner? What are the possible reasons for these differences?
4. What do these observations mean for the use of NPV in managing insect pests?
5. What do these observations mean for the use of fungicides in managing crop diseases?

# **Pesticides**



## UNDERSTANDING FARM PESTICIDE LABELS

### **Introduction**

The main objectives of IPM training are helping farmers to increase their knowledge, enabling them to take maximum advantage of ecological relationships to control pests, and to reduce their pesticide use as much as possible in order to protect the environment and produce clean agricultural products. However, in some specific cases, pesticide use is necessary. How much do farmers understand about the kind of pesticide they want to buy? How can we help farmers to avoid making mistakes when choosing pesticides?

In Vietnam, all pesticide companies have their own logo and labels for their products. However, most Vietnamese farmers pay attention only to the effects of pesticides; few of them look at other information on the label before they buy a pesticide. This exercise will help farmers to understand in-depth the information that is printed on labels of pesticide containers/packets. They should then be able to make better decisions when choosing pesticides to protect public health and the environment.

### **Objective:**

Explain the signs and information printed on pesticide labels, including safety precautions

### **Materials:**

Pesticide labels (Ask farmers to bring labels from pesticides that they are using to raise awareness about the kinds that they are using, i.e., highly hazardous, etc. The trainers should also collect as many pesticide labels in case farmers do not bring any or there are not enough samples.

Papers and pens enough for five farmer groups

**Time:** 90 minutes

### **Method:**

1. The trainer should divide the pesticide labels into different groups, for example: insecticides, fungicides, herbicides OR extremely hazardous, moderately hazardous, slightly hazardous groups, etc.
2. The trainer should ask farmers to work in their small groups. Give each group some pesticide labels and ask farmers to bring out the labels they brought for the session.
3. Ask everybody to observe, read, and discuss carefully about the information and signs printed on the pesticide labels.
4. Members in each group explain the signs and information printed on pesticide labels to each other.
5. Discuss in the big group.

### **Discussions:**

1. How many kinds of information are printed on a pesticide label? What is the information about? Which are the most important parts of the label? Why?
2. What is the trade name? What is the common name? Which one – trade or common name - expresses the essence of a pesticide? Why does one common name have many trade names?
3. Are the colors of the bars at the bottom of pesticide labels similar? What does the color of the bar mean? Looking at pesticide labels, how do you know if one pesticide is more hazardous than others? Explain the signs printed on the indicative color bar. Have the farmers ever paid attention to these signs? Why? If the indicative color bar of the pesticide label in your hand is red, what do you do with this pesticide?

4. What do the labels say about how to avoid pesticide poisoning during mixing and spraying? What do they say about what to do first if you are exposed to pesticide? What do farmers actually do? Why? According to your group, through which routes do pesticides enter human body?
5. In the past, if you needed to buy a pesticide, how did you choose which pesticide to buy? Why?
6. Were there information on the labels that were not true? Give examples.
7. In the opinion of your group, what information is missing on the labels?

## WHAT IS AN LD<sub>50</sub>?

### Introduction

Test on the dosage of insecticide which kills test animals are called Lethal Dosage tests. Basically the process is simple and depends on the fact that not all animals will die with the same dosage because some individuals are more sensitive than others. If a very low dose is applied to 100 individuals, only a few individuals will die. If a very high dose is given, then most of the 100 individuals will die. The dose at which 50 of the 100 (50%) die is called the 50% lethal dosage or LD<sub>50</sub>. The dosage at which 90 of the 100 individuals (90%) die is called the LD<sub>90</sub>. This is a moderately useful measure, except that even at low dosages there is still an LD<sub>10</sub> in which 10% die. What does this 10% probability mean in another example? It means that there is a probability that for every ten people that cross the road, one will die while crossing the road. In other words, 10% probability is still very high. Dosage for mammal is usually measured in mg/kg. This means that a LD<sub>50</sub> of 1 mg/kg (the oral LD<sub>50</sub> for *Thiuram* for a person who weighs 50kg is about 50mg, which is a very small quantity. Lethal dosages are usually given in both oral (through the mouth) and dermal (exposure to skin) levels.

### Objective:

Explain what is an LD<sub>50</sub> measure

### Materials:

Graphing paper and pencils

**Time:** 60 minutes

### Method:

- The following are the results of several trials for different dosage levels.

Trial Dosage	100 test individuals		Alive
	Dead		
0 ppm	1	99	
30 ppm	2	98	
60 ppm	3	97	
90 ppm	10	90	
120 ppm	25	75	
150 ppm	45	55	
180 ppm	65	35	
250 ppm	85	15	
300 ppm	90	10	
400 ppm	95	5	

- Graph the trials. Use dosage on x-axis, and % dead on the y-axis.
- According to the data, what is the LD<sub>10</sub>, LD<sub>50</sub>, and LD<sub>90</sub> for this population of 100 individuals?
- In a cabbage field, if there are four diamondback moth per plant and the planting distance is 50 X 40, how many diamondback moth are killed when a spray at the LD<sub>50</sub> is used? How many are alive? What do you think is the best dosage to use for field application? How about at the LD<sub>90</sub>? What do you think farmers are doing?
- Natural enemies are usually more susceptible to insecticides than pests because natural enemies usually do not build up resistance. What happens when a low dosage is applied to the field (i.e., a dosage that is LD<sub>20</sub> for diamondback moth, but LD<sub>95</sub> for natural enemies)?



2. Define oral LD<sub>50</sub>. Give an example. What are the LD<sub>50</sub> oral and dermal of legal compounds in vegetables?

**Discussions:**

Present your results and definitions.

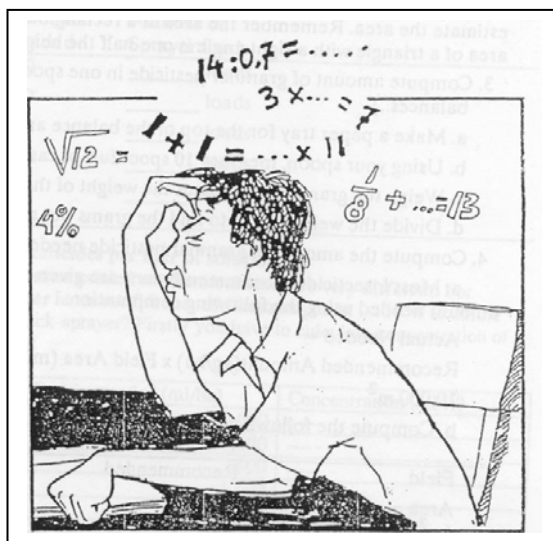
## PESTICIDE CALCULATIONS

### Introduction

There are some who claim that farmers cannot do IPM because it is too complex. These same people claim that simple pesticide recommendations are “easier”.

In fact, IPM is not too complex for anyone to implement, and pesticides are not easy to use. Pesticide calculations are somewhat complicated for proper application based on plot size, dosage, and calibration (rate of spraying).

In this activity, we will investigate the typical calculations needed for recommended pesticide applications and how to provide farmers with useful measuring methods.



### Objectives:

- Find the area of a field
- Compute the amount of poison needed to cover the field

### Materials:

Meter stick  
Paper  
Pencils  
Weighing scale  
Spoons

**Time:** 120 minutes

### Method:

(DO NOT USE A CALCULATOR; USE PENCIL AND PAPER)

1. To measure your foot step:
  - a. Lay the meter stick on the ground for about 12 meters.
  - b. Take ten steps next to the meter stick and measure the length of ten steps.
  - c. Divide the length by ten to get the average footstep length.
  - d. Try to make a step that is exactly 0.5m or 1.0m. This will make calculations of area easier.
2. Compute the area of fields (most farmers say they know, but few farmers actually know the area of fields):
  - a. Make a map of the field with the approximate shape.
  - b. Measure the sides of the fields by walking and counting the steps.
  - c. If the field is not a rectangle, then divide the field into rectangles and triangles to estimate the area. Remember the area of a rectangle is the height times the width. The area of a triangle with a right angle is one-half the height times the base.
3. Compute amount of granular pesticide in one spoonful; (for farmers without balances.)
  - a. Make a paper tray for the top of the balance and write down the weight.

- b. Using your spoon, measure ten spoonfuls of Carbosulfan 5G.
  - c. Weigh the granules and minus the weight of the paper.
  - d. Divide the weight by ten to find the grams per spoonful.
4. Compute the amount of granular pesticide needed for a field.
- a. Most insecticide recommendations are given based on 1 ha. Compute the actual amount needed using the following computation:

$$\text{Actual Needed} = \frac{\text{Recommended Amount (kg/ha)} \times \text{Field Area (m}^2\text{)}}{10,000\text{m}^2}$$

- b. Compute the following:

Field Area (m <sup>2</sup> )	Recommended Amount (kg/ha)	Actual Amount (kg)	Number Spoonfuls Needed
800m <sup>2</sup>	17kg/ha	_____kg	_____spoons
1200m <sup>2</sup>	8.5kg/ha	_____kg	_____spoons
750m <sup>2</sup>	17kg/ha	_____kg	_____spoons
1050m <sup>2</sup>	12kg/ha	_____kg	_____spoons
350m <sup>2</sup>	10kg/ha	_____kg	_____spoons

5. Compute the amount of liquid in a spoonful.  
Most liquid pesticide recommendations are given in ml. To find the number of ml. in a spoon, put ten spoonfuls of water in a measuring glass. Read the measurement and divide by ten to get the number of ml. in a spoonful.
- 6. Compute the number of sprayer loads and number of spoonfuls of pesticides needed for a field.
    - a. To spray a field, usually 200 to 500 liters per hectare are required. In the early stages, 200 liters per hectare is sufficient. In the later stages, 400 liters is necessary because there is more foliage to cover. These are recommendations which are not usually implemented for good reasons (weight, time, access to clean water, etc.) To properly compute the number of tank loads, simply divide the amount required by the number of liters in the sprayer.
    - b. Compute the following:

Sprayer size	Amount needed	Number of sprayer loads
111	300	_____ loads
131	500	_____ loads
151	300	_____ loads
91	400	_____ loads
131	500	_____ loads

- c. Define concentration of pesticides per liter of solution  
In many cases, the application rates printed on pesticide labels are very different. For example: Use 1.0 liter of BT per ha or use 1.5 liter of Bassa per ha. How do you define the amount of pesticide per one back-sprayer? Firstly, you have to calculate the concentration of pesticide needed, as follows:

Solution needed	Recommended (ml/ha)	Concentration (ml/l) ?
-----------------	---------------------	------------------------

*Pesticides*

(liters/ha)		
300	1,000	?????
400	1,200	?????
500	800	?????
300	1,500	?????
500	2,000	?????
400	500	?????
.....		

- d. Now for each sprayer load, some insecticide must be added. You have to multiply the usual recommendation of number of ml. per liter to get the total ml. needed for the sprayer. Then you must figure the number of spoonfuls enough for that number of ml. The number of spoonfuls is the total number of ml. divided by the number of ml. per spoonful.

Sprayer size	Recommended ml/l	Total ml/load	Number of spoonfuls needed
111	2 ml/l	_____ml	_____ spoons
111	3 ml/l	_____ml	_____ spoons
131	5 ml/l	_____ml	_____ spoons
131	2 ml/l	_____ml	_____ spoons
151	3 ml/l	_____ml	_____ spoons
151	4 ml/l	_____ml	_____ spoons

**NOW YOU CAN SEE THAT PESTICIDES ARE POISONOUS AND THE COMPUTATIONS ALSO GIVE YOU A HEADACHE!**

(Thank you to ideas and field studies from Dr. James Mangan.)

## **SPRAYING**

Adapted from Helen Murphy's Guide for Farmer-to-Farmer IPM Health Studies

### ***Introduction***

Spraying pesticides is dangerous. The compounds used for spraying are in a concentrated form which makes them even more dangerous than usual exposure. Concentrated liquids direct from the bottle, and exposure to sprays in the field during application causes numerous symptoms such as skin rashes, dizziness, nausea, and headaches. The usual recommendation for gloves, boots, rain clothes, and respirator are impossible to implement for most farmers because of the costs. While some farmers use "protective" clothing they do not fully understand how pesticides enter the body and how so-called "protective" clothing does NOT guarantee that contamination will not occur.

There are many other precautionary measures that should be taken to reduce exposure to poisons when spraying. For example, the direction and velocity of the wind should be considered. If the wind is blowing hard, farmers should not spray. The chemical will never reach most of the plant. Never walk into the wind when spraying. Always walk at a 90 degree angle to the wind. This exercise will help participants understand is there is really "safe application" of pesticides.

### **Objectives:**

- Discuss that protective clothing is NO guarantee against exposure to pesticides
- Discuss if there is really "safe application" of pesticides

**Time:** 120 minutes

### **Materials:**

Sprayer  
Bucket  
Red dye  
White pants  
Shirt  
Gloves  
Mask  
Cigarette  
Snacks to be eaten with the hands  
Cup of water for drinking  
Newprints and markers

### **Method:**

1. The facilitator should mention that in real life, participants/farmers should observe precautionary measures to reduce exposure to poisons. These include the maintenance and preparation of the equipment, the preparation of the pesticide, wearing appropriate clothing, using appropriate spraying techniques, etc. (For details, see examples in table under section on Discussions.) However, in this exercise, participants should be able to observe farmers' common practices, mostly incorrect, practices in spraying. These will be the basis for later discussions. (More incorrect practices demonstrated and observed will lead to more discussions on what can be done to reduce exposure to poisons.) Stress that the exercise is intended to initiate discussions on whether or not there is really "safe application" of pesticides.
2. All participants go to the field. One person in the group will play the role of a "farmer". This person should put on the white pants, shirt, gloves, and mask – to make it easier to see the red dye ("pesticide") stains. The "farmer" will show common practices, MOSTLY INCORRECT, practices in spraying. The "farmer" may exaggerate for emphasis.
3. The other members of the group should make notes on what the "farmer" is doing. Also note how the "farmer" could have reduced exposure to the spray liquid.

## Pesticides

4. The “farmer” should fill the tank with water and add red dye. Add a lot so that the water is very red. Close the tank and shake the tank to mix the water and the dye. (Farmers often mix pesticides with their bare hands.)
5. The “farmer” will spray 500 m<sup>2</sup> of the field with the tank of water and dye using 2-3 tanks (as farmers practice) and take a break between spraying to smoke, eat with hands and drink from a cup (without washing hands). The “farmer” sprays without checking the direction or velocity of the wind. Others should measure the time required and observe the spraying technique.
6. After finishing spraying, the “farmer” empties the excess mixture from the tank. (Farmers normally empty tanks into irrigation canals.)
7. Now observe the sprayer. Is the red dye on the skin or clothing of the person who sprayed? Using a piece of newsprint, ask each group to draw the points of contamination. Use red color to show pesticide contamination.

### Discussions:

1. Process the activity by eliciting observations taken on the role play/demonstration. (More incorrect practices demonstrated and observed will lead to more discussions on what can be done to reduce exposure to poisons.) Use the following table as an example:

What the “farmer” did	What should the “farmer” have done
The “farmer” did not clean the sprayer.	If the sprayer has been used before, wash it thoroughly with detergent. Use gloves when washing the sprayer. (Another possible answer: The owner of the sprayer should clean it before keeping to avoid corrosion and clogging.)
The “farmer” used his mouth (blew) to clear the clogged hose.	Check to see if the sprayer is working properly by pumping and spraying water. This will also clean the hose and nozzle of the sprayer. If necessary, use water or a soft probe like a weed stem to clean the hose and clear the holes of the sprayer.
	Take note of the size and type of the nozzle to see if this suits your requirements. (Farmers may not have very much choice about sizes and types as they might only have one nozzle!)
The “farmer” did not measure the red dye put just put it inside the sprayer.	Check the recommended dosage on the label or ask help from a neighbor or another family member if the farmer can not read and do calculations. (Higher doses do not produce better effects; lower doses will be less effective.)
The “farmer” used his bare hands for mixing the “chemical”.	Use a long disposable stirrer to mix the pesticide and properly dispose of the stirrer.
The “farmer” had red dye all over his back – the sprayer was leaking.	Check for leaks by carrying the tank and spraying with water.
The “farmer” sprayed against the wind.	Check for the direction and velocity of the wind. If the wind is blowing hard, do not spray. Never walk into the wind when spraying. Always walk at 90 degrees angle to the wind.
The “farmer” was smoking while spraying.	Do not smoke while spraying; use a mask while spraying.
The “farmer” ate without washing his hands.	Wash hands thoroughly with soap and water after handling pesticides and especially before eating.

The “farmer” emptied his tank into the irrigation canal.	Use all the pesticides in the field. (Depending on the product, surplus may or may not be used the following day.)
The “farmer” left the empty “pesticide bottle” (red dye container) in the field.	Etc.
Etc.	Etc.
Etc.	Etc.
Etc.	Etc.
Etc.	Etc.

2. What signs and symptoms of poisoning can be caused by pesticides?
3. What are the experiences of the groups with spraying pesticides?
4. Discuss the easiest ways for pesticides to enter the body (SKIN, WET CLOTHES) and increase the risk of pesticide poisoning.
5. Discuss that the MOST important time when contamination leading to poisoning occurs is during mixing the pesticide concentrates. . .which is WORSE when using a pre-mixed pesticide cocktail!
6. Discuss that protective clothing is NO guarantee that contamination will not occur, but ask what low cost practical measures can be taken to reduce skin contamination.
7. Present the following situation: *A farmer sprays for two hours. He only changes clothes and takes a bath four hours after spraying.* (Note: The farmer’s skin is not exposed just two hours but six hours because his skin has continued contact with pesticides for the extra four hours between finishing spraying and taking his bath.) Ask for ideas of everyone in the group. Discuss importance of bathing with SOAP immediately after spraying and always using freshly washed clothing for spraying.
8. How can farmers reduce the exposure to pesticides?
9. Discuss "Is there really 'safe application' of pesticides?"

## **SELF-SURVEY OF PESTICIDE POISONING**

Adopted from Helen Murphy's Guide for Farmer-to-Farmer IPM Health Studies

### **Objectives:**

- Recognize signs and symptoms of pesticide poisoning
- Discuss how through IPM experimentation with non-chemical alternatives to pest management, pesticide related illness can be eliminated

### **Materials:**

Signs and symptoms of pesticide poisoning body map (body and head)

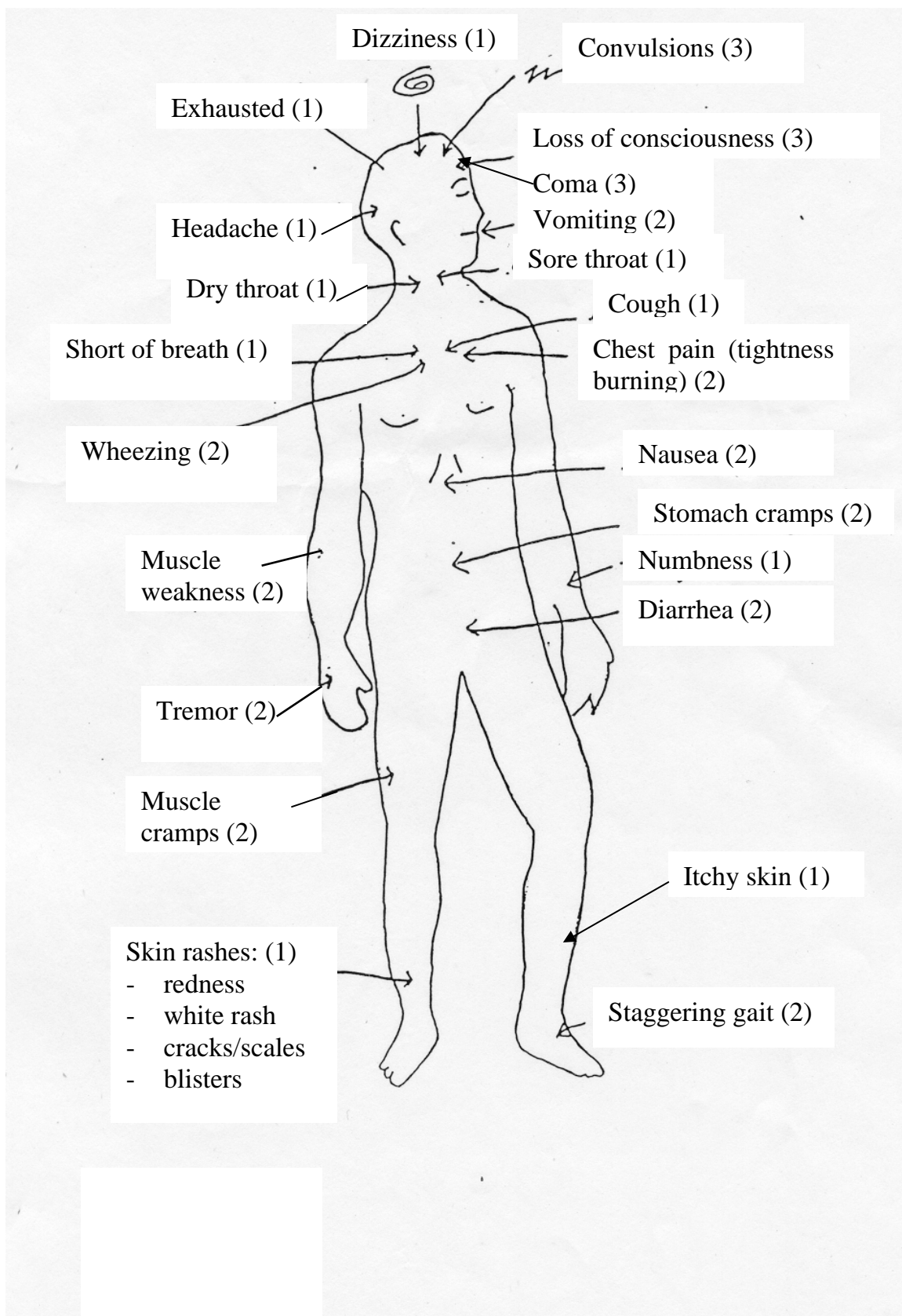
### **Method:**

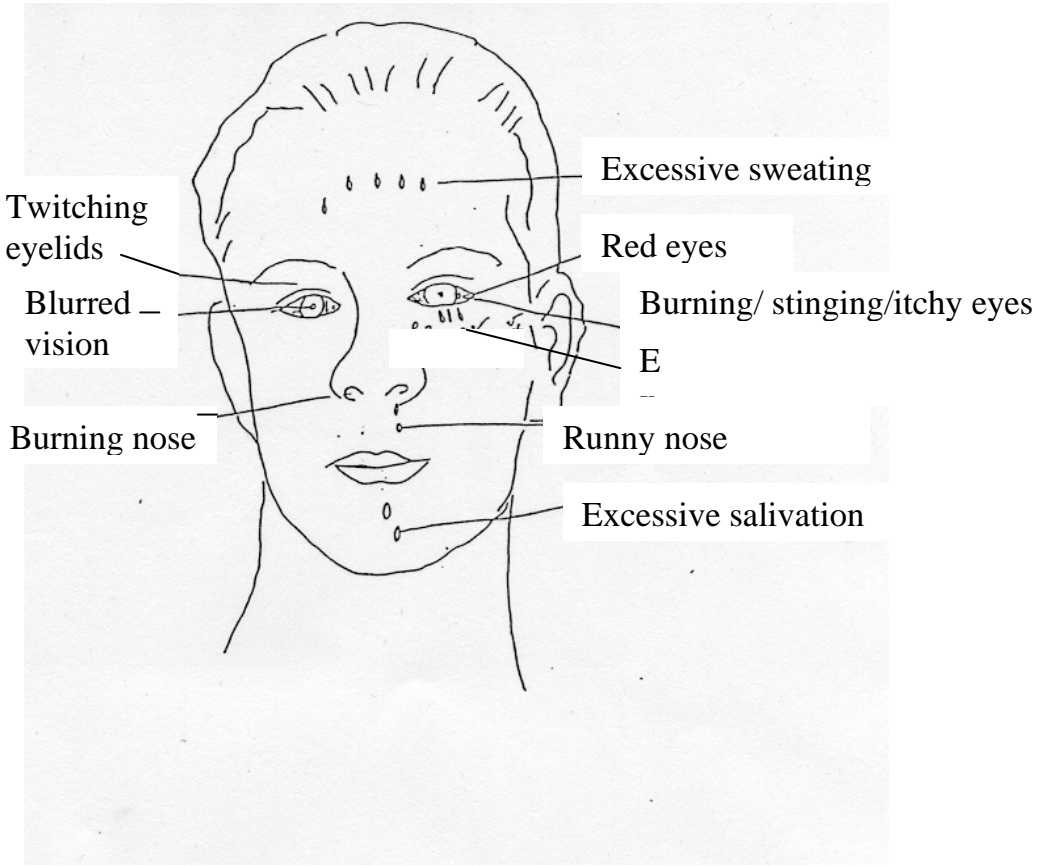
1. Distribute body maps to each farmer.
2. Explain DEFINITION of each sign and symptom.
  - Discuss *other* conditions or illnesses that could cause the sign and symptom.
  - Discuss how to identify the signs
3. Ask each farmer to circle or check each sign and symptom 'ever experienced' during or up to 24 hours AFTER spraying.
  - If any farmers are illiterate divide into groups with one reader per group.
  - Farmer may add a sign and symptom not on the list that they feel are associated.
4. Tabulate results on a master picture by a raise of hands poll.
5. Calculate percent ( $\#/\text{total farmers} \times 100$ ) of each sign and symptom experienced.
6. Poll farmers level of pesticide poisoning:
  - Mild poisoning = only (1's) marked
  - Moderate poisoning = at least one (2) marked
  - Severe poisoning = at least one (3) marked
7. Discuss definition of mild, moderate and severe
  - Mild = sign or symptoms only from irritation or a vague symptom
  - Moderate = a nervous system sign or symptom
  - Serious = loss of consciousness or seizure

### **Discussions:**

Discuss how through IPM experimentation with non-chemical alternatives to pest management, pesticide related illness can be eliminated.







## YEARLY PESTICIDE LITERS OF EXPOSURE

Adopted from Helen Murphy's Guide for Farmer-to-Farmer IPM Health Studies

### Objectives:

- Calculate yearly pesticide liters of exposure
- Discuss how through IPM farmers can reduce spray frequency (or totally eliminate spraying depending on future non-chemical IPM alternatives discovered through IPM experimentation)

### Materials:

Calculators

### Method:

1. Ask farmers to calculate yearly pesticide liters of exposure using the table below:

AMOUNT OF PESTICIDES USED BY FARMERS							
Crop	a. Tank size (li.)	b. # of tanks per spray session	c. ♦ # of spray sessions per week	d. ♦ # weeks per season	e. # of spray sessions per season (c*d)	f. seasons per year	Liters exposure per year a*b*e*f
<b>TOTAL</b>							

♦ fill in column 'c.' and 'd.' only if spraying on a weekly basis. Otherwise use column 'e.' showing how many spray sessions per season.

### Discussions:

1. Discuss how through IPM farmers can reduce spray frequency (or totally eliminate spraying depending on future non-chemical IPM alternatives discovered through IPM experimentation).
2. Ask farmers to recalculate yearly pesticide liters of exposure using a lower number of spray sessions per season.
3. Compare the difference in liters of exposure between first and second calculation. Talk about the health and economic benefits if a farmer sprays less often.

## **HOUSEHOLD STORAGE AND DISPOSAL OF PESTICIDES**

Adapted from Helen Murphy's Guide for Farmer-to-Farmer IPM Health Studies

### **Objectives:**

Discuss how farmers can reduce risks of pesticide poisoning through proper household storage and disposal of pesticides

### **Materials:**

Paper and markers

### **Method and Discussions:**

1. Ask each farmer to draw a picture of his house and farm showing the locations of the following:
  - Food storage
  - Food preparation
  - Food consumption
  - Drinking and cooking water source
  - Drinking and cooking water storage
  - Drinking and cooking water use
  - Location of all farm animals (chickens, pigs, ducks, cows, etc.)
  - Where pesticide containers are thrown out
  - Where tank is stored
  - Where pesticides are stored (and height from ground)
2. Display each drawing on the walls.
3. Each farmer walks around the room (like an art gallery) and answers the following questions (yes/no) for each household drawing:
  - Storage:
    - a. Is pesticide storage safe for children?
    - b. Does pesticide storage prevent drinking and cooking water contamination?
    - c. Does pesticide storage prevent food contamination?
    - d. Is pesticide storage safe for farm animals?
  - Disposal:
    - a. Is pesticide disposal safe for children?
    - b. Does pesticide disposal prevent drinking and cooking water contamination?
    - c. Does pesticide disposal prevent food contamination?
    - d. Is pesticide disposal safe for farm animals?
4. Tally the results on a master list (number and %)
5. Discuss why the answers are 'no' picture by picture. Define with group what constitutes unsafe storage and disposal.

## PESTICIDES AND PEST RESISTANCE

### ***Introduction***

A pest is said to have developed resistance to a certain pesticide when it loses sensitivity to the material. Resistance may develop in relation to the actual dose, the concentration, or the exposure time to a certain pesticide. To measure the degree of resistance that a pest has developed, it is necessary to have a control treatment. It is also important to remember that when doing experiments especially with insect pests, care must be taken so that the insects are not damaged during handling resulting in deaths not directly related to pesticides.

### **Objective:**

Try out different dosages of chemical insecticides on different larval stages to observe the development of pest resistance to chemical insecticides

### **Materials:**

Chemical pesticides (five different kinds of chemical insecticides commonly used in the area for each group)

Larvae at different stages

Hand sprayers (one liter capacity)

Masks

Plastic or rubber gloves

Scissors

Forceps

Long disposable stirrers for mixing pesticides

Containers for mixing pesticides

Plastic cups with organdie sheets and rubber bands

Pens

Notebooks

### **Method:**

In the session room:

1. All groups should collect fresh leaves from the upper part of the cabbage, tomato, or French bean plant. Cut leaves into 1" diameter sections.
2. Participants should prepare the hand sprayers before setting up the exercise. If the sprayers have been used before, wash them thoroughly with detergent. Use gloves when washing the sprayers. Check to see if the hand sprayers are working properly by pumping and spraying water. This will also clean the hose of the sprayer. If necessary, use water or a soft probe like a weed stem to clean the hose and clear the holes of the sprayer.
3. Participants should carefully read the instructions on how to use each pesticide product as printed on its label. Following the recommended dose (This differs from product to product!), participants will prepare the different pesticides. Trainers should call attention of participants to the correct dosage and appropriateness of mixing procedures – whether the pesticide product is in powder or suspension form!
4. Also pay attention to how participants calibrate the pesticide to use in one liter of water. (Note: If using a suspension, make sure to shake the bottle thoroughly to disperse the solution evenly. Choose a syringe with a needle hole big enough to take up the suspension. If using a pipette, take up more than the volume required and release the excess back into the suspension bottle to get the exact quantity. Never use the mouth to suck the suspension into the pipette!)
5. The members of the group handling the pesticides should put on masks (Homemade masks from discarded brasierre pads are useful!) and plastic or rubber gloves. Use a long disposable stirrer for each kind of product that will be used to prepare the solution and properly dispose of the stirrer.

6. Each group should do five treatments, i.e., use five different kinds of chemical insecticides commonly used in the area. Each treatment should have three replications. Each group should then have a total of fifteen cups labeled accordingly. Members of the group who will set up the treatments should also use masks and gloves as well as handle leaf sections with forceps.
7. Using hand sprayers, spray the chemical insecticides on the leaf sections and let dry. When dry, put a leaf section into each plastic cup lined with tissue paper and introduce 10 – 20 larvae (depending on the stage of the larvae). Each cup should be covered with organdie sheets held securely with rubber bands.
8. Observe after 12 hours, 24 hours, 48 hours, and 72 hours. Record observations on table suggested below taking note of the leaf damage, frass production, and the state of the larvae.
9. Remember: Dispose properly of empty pesticide containers to prevent pollution of the environment and any possible contamination. If you need to store unused pesticides keep them in a cool place that is safe for people (especially children) and animals. Wash hands thoroughly with soap and water after doing the exercise and each time you handle pesticides!
10. Trainers should call attention of participants to the need to handle, use, dispose, and store pesticide products properly and with caution. These are poisons!

### In the field:

1. Each group should select fifteen individual plants in the field to carry out five treatments using five different kinds of chemical insecticides commonly used in the area. The same products used in the session room exercise may be used for the field exercise. Each treatment should have three replications.
2. Observe the pest population on each plant and classify the larval stages. Note down the pest population according to the larval stages.
3. Participants should prepare the hand sprayers before setting up the exercise. If the sprayers have been used before, wash them thoroughly with detergent. Use gloves when washing the sprayers. Check to see if the sprayers are working properly by pumping and spraying water. This will also clean the hose of the sprayer. If necessary, use water or a soft probe like a weed stem to clean the hose and clear the holes of the sprayer.
4. Participants should carefully read the instructions on how to use each pesticide product as printed on its label. Following the recommended dose (This differs from product to product!), participants will prepare the different pesticides. Trainers should call attention of participants to the correct dosage and appropriateness of mixing procedures – whether the pesticide product is in powder or suspension form!
5. Also pay attention to how participants calibrate the pesticide to use in one liter of water. (Note: If using a suspension, make sure to shake the bottle thoroughly to disperse the solution evenly. Choose a syringe with a needle hole big enough to take up the suspension. If using a pipette, take up more than the volume required and release the excess back into the suspension bottle to get the exact quantity. Never use the mouth to suck the suspension into the pipette!)
6. The members of the group handling the pesticides should put on masks (Homemade masks from discarded brasierre pads are useful!) and plastic or rubber gloves. Use a long disposable stirrer for each kind of product that will be used to prepare the solution and properly dispose of the stirrer.
7. Members of the group who will set up the treatments should also use masks and gloves. Using hand sprayers spray the chemical insecticides on the individual plants and label treatments accordingly. Spray the chemical on the upperside of leaves moving from the top towards the bottom portion of the plant. Then spray the chemical on the underside of leaves moving from the bottom towards the top portion of the plant. Make sure that both sides of the leaves are drenched with the solution. Spray following the direction of the wind. Wash hands thoroughly with soap and water, and change clothes after spraying.
8. Observe after the first 24 hours and continue taking observations until the fifth day. Record observations on table suggested below taking note of the leaf damage, frass production, and the state of the larvae.

9. Remember: Dispose properly of empty pesticide containers to prevent pollution of the environment and any possible contamination. If you need to store unused pesticides keep them in a cool place that is safe for people (especially children) and animals. Wash hands thoroughly with soap and water after doing the exercise and each time you handle pesticides!
10. Trainers should call attention of participants to the need to handle, use, dispose, and store pesticide products properly and with caution. These are poisons!

**Discussions:**

1. Describe differences in the treatments in the cups and in the field.
2. What do these observations imply for crop production?

*Pesticides*

TREATMENT		Pesticide A			Pesticide B			Pesticide C			Pesticide D			Control (water)		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Leaf damage	12															
	24															
	48															
	72															
Frass production	12															
	24															
	48															
	72															
State of larvae	12															
	24															
	48															
	72															
Total	12															
	24															
	48															
	72															

**SCORING SYSTEM**

**LEAF DAMAGE**

- 1: low
- 2: moderate
- 3: high

**Frass production**

- 1: none
- 2: little
- 3: much

**State of larvae**

- 1: dead
- 2: moribound
- 3: active



## EFFECT OF PESTICIDES ON PREDATORS

### Method:

Recent studies on vegetables suggest that ground predator fauna is rich in unsprayed fields in Asia, but is strongly eliminated by insecticides.

1. All groups choose four 10x10 m plots inside a homogenous cabbage, tomato, or French bean field (two sprayed as farmers' practice, two unsprayed). If possible, have a 3-5 m stretch as a buffer zone between the plots.
2. Participants weekly record predator densities (crickets, red fire ants, black predator ants, lycosid spiders, other spiders, carabid beetles, staphilinid rove beetles) at dusk, or very early morning/evening, using 50x50x30 cm quadrants.
3. Group members take about ten samples from each treatment, sprayed and unsprayed (i.e. five samples per plot) and compare the seasonal densities.
4. [Additional pitfall traps (e.g. 250 ml plastic or glass jars half filled with water, buried in the soil up to the rim of the jar) may be put in a regular pattern within the same plots to record the activity of ground predators. Pitfall traps containing water should remain in the field for only about two days to avoid decomposition of trapped arthropods (If poisonous formaline is used, the pitfall trap can remain in the field for 1 week periods).]
5. In addition to sampling predators, this trial can be used to study the effect of spraying on *Spodoptera* and on the parasitism level.

## **EFFECTS OF PESTICIDES ON NATURAL ENEMIES**

### **Objective:**

Evaluate the effect of sprayed leaves on the survival of natural enemies

### **Materials:**

Four jars with lids

Four pieces of Muslin cloth with rubber bands, to close jars (Method 2)

Labels

Scissors

Forceps

Long disposable stirrers for mixing pesticides

Masks

Plastic or rubber gloves

Paper, pen

Four small handsprayers (0.5 liter)

Small amounts of insecticides

### **Method 1:**

1. Participants prepare four hand sprayers before setting up the exercise. If the sprayers have been used before, wash them thoroughly with detergent. Use gloves when washing the sprayers. Check to see if the sprayers are working properly by pumping and spraying water. This will also clean the hose of the sprayer. If necessary, use water or a soft probe like a weed stem to clean the hose and clear the holes of the sprayer.
2. Participants should carefully read the instructions on how to use the product printed on the label. Following the recommended dose at field rate concentrations (This differs from product to product!), participants should prepare the different pesticides. Trainers should call attention of participants to the correct dosage and appropriateness of mixing procedures – whether the pesticide product is in powder or suspension form!
3. Also pay attention to how participants calibrate the chemical to use in 0.5 liter of water. (Note: If using a suspension, make sure to shake the bottle thoroughly to disperse the solution evenly. Choose a syringe with a needle hole big enough to take up the suspension. If using a pipette, take up more than the volume required and release the excess back into the suspension bottle to get the exact quantity. Never use the mouth to suck the suspension into the pipette!)
4. The members of the group handling the pesticides should put on masks (Homemade masks from discarded brasierre pads are useful!) and plastic or rubber gloves. Use a long disposable stirrer for each kind of product that will be used to prepare the solution and properly dispose of the stirrer.
5. Each group should prepare three handsprayers with commonly used insecticides for example: pyrethroid, carbamate (chemical insecticides), NPV or Bt (biological insecticide) and one handsprayer with water (control). That means that each group will carry out four treatments (three with chemical insecticides and one control).
6. Members of the group who will set up the treatments should also use masks and gloves. Select four plants in the field: one plant per spray treatment. Using hand sprayers spray the chemical insecticides on the individual plants and label treatments (plants) accordingly. Spray the chemical on the upperside of leaves moving from the top towards the bottom portion of the plant. Then spray the chemical on the underside of leaves moving from the bottom towards the top portion of the plant. Make sure that both sides of the leaves are drenched with the solution. Spray following the direction of the wind. Wash hands thoroughly with soap and water, and change clothes after spraying.
7. Let the leaves dry on the plant.
8. Pick one or several leaves from each treatment and transfer to glass jars. (Use gloves!) Label the jars. Each group should have one jar of each spray treatment (four jars in total). Try to get the leaf to lie flat on the inside surface of the jar.

9. Collect several predators from the field. Transfer them to the jars. Use the same predator species in all treatments. Close the jar with the lid, and place a piece of tissue paper between the jar and the lid to avoid condensation inside the jar.
10. Check and record the condition of the predators after eight hours and after 24 hours. Count the number of dead insects. It may be necessary to touch the insect with a pen or pencil to determine if it is dead. If it does not walk off in a normal manner, then record it as dead.
11. Remember: Dispose properly of empty pesticide containers to prevent pollution of the environment and any possible contamination. If you need to store unused pesticides keep them in a cool place that is safe for people (especially children) and animals. Wash hands thoroughly with soap and water after doing the exercise and each time you handle pesticides!
12. Trainers should call attention of participants to the need to handle, use, dispose, and store pesticide products properly and with caution. These are poisons!

**Method 2:**

1. Participants prepare four hand sprayers as in Method 1.
2. Members of the group who will set up the treatments should use masks and gloves. Spray each piece of muslin cloth with a sprayer and let the cloth dry. Label the cloth.
3. All groups collect several predators from the field and transfer them to four jars per group. Use the same predator species for all treatments. Close the jar with the sprayed muslin cloth.
4. Group members check and record the condition of the predators after eight hours and 24 hours. Count the number of dead insects. It may be necessary to touch the insect with a pen or pencil to determine if it is dead. If it does not walk off in a normal manner, then record it as dead.
5. Remember: Dispose properly of empty pesticide containers to prevent pollution of the environment and any possible contamination. If you need to store unused pesticides keep them in a cool place that is safe for people (especially children) and animals. Wash hands thoroughly with soap and water after doing the exercise and each time you handle pesticides!
6. Trainers should call attention of participants to the need to handle, use, dispose, and store pesticide products properly and with caution. These are poisons!

## **POISON SPRAYER MAINTENANCE**

### ***Introduction***

Pesticides are not medicines! They are poisons to be used and handled with great care. Some granular chemicals can be broadcast (using gloves and boots). But many compounds are liquid and need to be sprayed on the crop.

Proper maintenance of the sprayer is necessary to avoid direct exposure from leaking valves, leaking hoses, bad nozzles, and bad rubber rings on the tank openings. Many sprayers spill chemicals on to the back of farmers as they are spraying.

Proper maintenance is also required to have complete coverage of the plant. A nozzle that is old or clogged will not give good coverage of the plant. Many poorly maintained sprayers put out a stream of poison like a person urinating. This wastes money, and exposes the farmer to heavy dripping of the poisons. The spray should be small droplets and spread over the entire spray path.

In this activity, we will look at how to maintain a sprayer.

### **Objectives:**

- Identify parts and function of a sprayer
- Take apart and put a sprayer back together

### **Materials:**

Sprayer  
Bucket  
Hand tools for disassembling the sprayer  
Large piece of cloth or paper

**Time:** 90 minutes

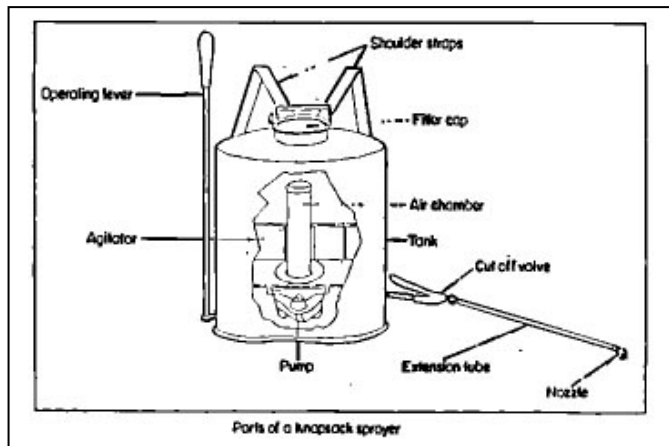
### **Method:**

1. In a shady place, sit down in a group with one sprayer. Have one bucket of water and tools ready to be used before beginning.
2. The sprayer is made of many parts. Look at the sprayer and identify all the parts and their functions.
3. Fill the tank with clean water and operate the sprayer. Test the pump and valves. Note any leaks when the sprayer is being operated and when it is on its side.
4. Now empty the sprayer back into the bucket. Begin to disassemble the sprayer. Someone should keep track of how the sprayer is built so that it can be put back together. Make sure the pieces are placed on the cloth or paper. Any dirt on the pieces will cause problems when the sprayer is put back together.
5. Locate all the potential places for leaks.
6. Practice changing the rubber rings. Practice explaining what the rubber rings are used for.
7. Now look at the nozzle.
8. After you have examined all the parts, put the sprayer back together. Fill the tank with water. Check for leaks and check to see if the sprayer is working.

### **Discussions:**

1. How do the rubber rings appear? Are they new or old? Were all the parts put together tightly so that the rubber ring is compressed? If the rubber ring is old, where do you buy a new one? Can you make one from an inner tube of tire? Are the seals on the top of the tank still good?

- If the farmer bends over with the sprayer on his back does the pesticide go on his back or head? Is there any corrosion on or in the tank?
2. Can the nozzle be adjusted? If so, how? What size of wire is needed to clean the nozzle (the wire should be smaller than nozzle hole)?
  3. How often should a sprayer be checked for problems? When should the rings be changed? When should the nozzle be changed?
  4. What is the cost of a new rubber ring? What is the cost of a new nozzle? What is the cost of pesticide poisoning from a leaking tank?



# **Diseases**



# Identification





## DESCRIPTION OF DISEASE SYMPTOMS

### **Introduction**

A training session on disease management could start with this group dynamics activity which will make participants aware of the importance of proper descriptions of symptoms and careful observation. This exercise resembles the situation when a farmer visits an extension office and describes the problem he has with his crop. It shows how difficult it is to make recommendations or decisions on what crop health management actions need to be taken without visiting a field and actually observing the crop.

### **Objective:**

Raise awareness of the need for field observations

### **Materials:**

Diseased plant material (different crops or different diseases per group)

Drawing paper and crayons

### **Method:**

1. Divide the group into smaller groups of four to five persons. Ask each group to isolate one of their members.
2. The isolated person is not allowed to see his/her fellow group members. The fellow group members are not allowed to see the isolated person. (It may help to put up a blackboard as a divider between the isolated person and the rest of the group. OR Ask the group to line up, with everyone facing one direction. Ask the isolated person to stand behind the line facing the opposite direction.)
3. Hand a diseased plant or diseased plant part to the isolated person. Ask the isolated person to describe the disease symptoms of the plant without mentioning the scientific name of the disease or any technical term. The isolated person may mention the common name of the disease.
4. The others in the group are asked to make drawings of the diseased plant only based on the isolated person's description. The other group members are not allowed to speak.

### **Observations:**

1. After about fifteen minutes, the drawings should be finalised.
2. Ask each group to present the drawings and explain about the disease they thought the sample was infected with.
3. Compare the drawings with the diseased specimen.

### **Discussions:**

1. Was it difficult to make the drawings?
2. Are the drawings accurate? Do they resemble the symptoms?
3. What does the drawing tell about the severity of the disease?
4. What does the drawing tell about the stage of the disease (spreading or not)?
5. Can one give advice on the management of a disease based on verbal description? Why or why not?

## **IDENTIFICATION OF DISEASE SYMPTOMS**

*(If working on cabbage, this exercise is more appropriate when the cabbage is in heading stage. For tomato and French bean it can be used when symptoms start to occur in the field.)*

### **Introduction**

Once the importance of field inspection in relation to disease identification has become evident, an exercise on different types of disease symptoms and about stages of severity of diseases in the field may be introduced. This exercise will show that one can group types of diseases and learn about the developmental stages of a disease in the field without knowing names of diseases.

### **Objectives:**

- Distinguish between different groups of disease symptoms (for cabbage: leaf spot, wilting, root diseases and rots; for tomato and French bean: leaf blights, wilting/root diseases, fruit symptoms like specks and rots)
- Compare developmental stages of each disease group

### **Materials:**

Vegetable field (cabbage, tomato or French bean, etc.) with different diseases in different progressive stages

Hand lens (at least one per group)

Drawing paper and crayons

### **Method:**

1. Visit the field and ask each group to collect as many different disease or disease-like symptoms in different progressive stages as can be found (so not only leaf spots but also other disease symptoms such as deformed roots, discoloured leaves, etc.)
2. Also collect plants with symptoms that might be caused by nutritional deficiencies.

### **Observations:**

1. In the meeting room, group the disease symptoms based on symptom groups like leaf spot diseases (including molds/mildews), wilts, fruit spots and rots, root disorders, shoot disorders and mosaics (including mottling).
2. Assign each disease group to a group of trainees.
3. Ask each group to rank the symptoms in order of severity.
4. Use the hand lens to check for spores of fungi. (Spores can sometimes be seen as moldy dusty appearance on a diseased area.)
5. Ask groups to draw the details of the different symptoms and disease development in color.
6. Avoid the use of scientific terms such as Latin names of diseases.

### **Discussions:**

1. Which diseases or disease groups are present?
2. What are the local names of the diseases?
3. Were symptoms caused by nutritional deficiencies or mechanical damage observed? Can you always distinguish these from diseases?
4. How do the disease symptoms look like? How do they start? What plant parts do the different diseases affect?
5. How do the diseases reproduce and spread? How can one find out?
6. Which are the most problematic diseases? Why?
7. How does the weather influence the development of diseases? During which season are the diseases most severe?
8. How can cultural practices influence the development of a disease? What non-chemical disease management practices are known to control the disease?
9. What methods can be used for a short-term control, which ones for long-term management?

## **DISEASE GROUPS**

### ***Introduction***

In order to be able to discover about disease management, one should appreciate information that is already available on life cycles of diseases. This exercise taps the information known by members of the group and links it up to practical field school situations. The exercise should not/does not “test” participants’ knowledge on diseases but summarizes the knowledge available and triggers creative thinking about how to find out about and manage diseases.

### **Objective:**

List down available information on disease ecology and management (rather than control) of diseases

### **Materials:**

Drawing paper and markers

### **Method:**

1. If the training course covers more than one crop, choose and focus on one crop at a time to avoid confusion. First, make a list of diseases of the crop using the following guide questions. Remind trainees that “I don’t know.” is a truly valid answer and a better answer than “I guess. . .” at all times.
  - What diseases of this crop do you know? (Use local names.)
  - What are the symptoms of the disease/s?
  - When does it occur?
2. When the list is completed, classify them according to disease group using the question: What is the causal organism of the disease: fungus, bacterium, virus or nematode? (Some participants may know about causal organisms. Some may not. Ask participants to recall earlier discussions on symptoms of the disease. Remember that the exercise should not/does not “test” participants’ knowledge on diseases but summarizes the knowledge available and triggers creative thinking about how to find out about and manage diseases.)
3. After completing the task of grouping the diseases according to disease groups, focus on the method of spread. Ask participants to recall their observations of diseases in the field and how they spread. Use the following questions:
  - Does the disease spread through water?
  - Does the disease spread through infected seeds?
  - Can it survive and multiply on weeds?
  - Can it survive on plant residues?
  - Can insects spread the disease?
  - Can humans spread the disease?If they are not certain, follow up each question with:  
What experiments can be designed and conducted to find out about this?
4. List information about disease groups per crop on poster paper and put them up on the walls. These posters may be used as reference during future sessions.

## **DISEASE GROUPS GAME**

*(This activity may be used as an icebreaker to start a session on disease groups.)*

### **Objective:**

Illustrate a simplified distinction of disease groups

### **Method:**

1. Demonstrate how to make movements to represent different disease groups. For example:
  - a bacterium places her hand behind the back, wiggles it like a tail, while circling in a spot
  - a fungus outstretches arms and fingers like a tree
  - a virus stands rigid and tall like a rod-structured virus particle
  - a nematode moves one arm like a snake
2. Everyone stands in a circle. An *'it'* stands in the middle of the circle and gives instructions. First, everyone in the group makes the movement that signifies the disease group that is called out by the instructor. When everyone is familiar with the movements, the game can start.
3. The *'it'* points randomly at a participant and calls out a disease group, e.g., nematode. The participant must show the movement that signifies the group mentioned, in this case, move one arm like a snake. In case the participant fails to show the correct movement, she is eliminated from the circle. The game continues until only one player is left.

## **IDENTIFICATION OF LATE BLIGHT**

*(This exercise is applicable only to late blight susceptible crops, such as tomato, potato, hot pepper, eggplant. If mold is observed, a follow-up exercise can be done on the same day: See Study of spread of a fungal leaf spot.)*

### **Objective:**

Identify late blight disease and describe the symptoms

### **Materials:**

Tomato, potato, eggplant or hot pepper field with incidence of leaf spot diseases  
Clean water  
Tissue paper  
Clear plastic bags or jars  
Hand lens

### **Method:**

1. Pick leaves with different lesions in the field.
2. Place leaves or leaf portions with lesions in separate plastic bags. Also insert some moist tissue in each bag.
3. Close the bags tightly but leave some air inside.
4. Keep the bags in a cool, shady place. Leave the bags overnight.

### **Observations:**

Next day, open the bags and observe the leaf portions. If you see mold on the underside of the lesions, then the lesion is caused by late blight. If not, another leaf spot disease may have caused the lesion.

### **Discussions:**

1. Can farmers use this test as a disease identification tool?
2. How can an identification tool (such as this) help farmers make management decisions?
3. What may have caused the lesion if late blight was not observed?

## **STUDY OF SYMPTOM DEVELOPMENT OF LEAF SPOTS: SESSION ROOM EXERCISE**

*(This exercise is best done at the same time as the field exercise.)*

### **Objective:**

Observe the symptoms of leaf spot diseases

### **Materials:**

Vegetable field with incidence of leaf spot diseases

Petri dishes, jars, clear plastic boxes

Tissue paper

Labels/tags

Poster paper, crayons, ruler, hand lens

### **Method:**

Visit the field and collect leaves with small leaf spots (early stage of disease).

In the session room:

1. Use whole leaves or cut leaf portions with small leaf spots onto discs of e.g. 10 cm diameter.
2. Using a marker, draw a big circle around the leaf spot that you want to study on each leaf or leaf portion.
3. Place each leaf or leaf portion in a petri dish lined with moist tissue paper. Close the lid.
4. In case petri dishes are not available, one can use clear plastic boxes with lids or clear plastic bags that can be closed tightly. Leave some air inside!

### **Observations:**

1. Measure the diameter of the leaf spot.
2. Draw each leaf spot and the area around the spot in detail, using crayons.
3. Use a hand lens to check for presence of any granular structures on the leaf spot (sporulation).
4. Observe the leaf spot each or every other day and regularly draw and measure the size of the leaf spot.
5. After one week, groups can be asked to present their findings.

### **Discussions:**

1. What happens with a leaf spot over time (color, structure, area around spot)?
2. What is the difference between a fungal leaf spot and a bacterial leaf spot?
3. What is the difference between a disease spot and insect injury? If the spot is caused by an insect injury, do you think that it would increase over time? Why or why not?
4. Is the leaf spot disease harmful to the crop?

## **STUDY OF SYMPTOM DEVELOPMENT OF LEAF SPOTS: FIELD EXERCISE**

*(This exercise is best done at the same time as the session room exercise.)*

### **Objective:**

Observe the symptoms of leaf spot diseases

### **Materials:**

Vegetable field with incidence of leaf spot diseases

Labels/tags

Poster paper, crayons, ruler, hand lens

### **Method:**

1. In the field, select a plant with a few small leaf spots on preferably young leaves.
2. Label the plant.
3. Tag the leaf with a small leaf spot.
4. Using a marker, draw a wide circle to mark the spot.

### **Observations:**

1. Measure the diameter of the leaf spot.
2. Draw each leaf spot and the area around the spot in detail, using crayons.
3. Use a hand lens to check for presence of any granular structures on the leaf spot (sporulation).
4. Observe the leaf spot each or every other day and regularly draw and measure the size of the leaf spot.
5. After one week, groups can be asked to present their findings.

### **Discussion:**

1. What happens with a leaf spot over time (color, structure, area around spot)?
2. How can one recognize the first beginnings of a leaf spot?
3. What is the difference between a fungal leaf spot and a bacterial leaf spot?
5. What is the difference between a disease spot and insect injury? If the spot is caused by an insect injury, do you think that it would increase over time? Why or why not?
4. What was the effect of the weather during the experiment?
5. If the exercise was done simultaneously with the session room exercise: Was there a difference in the development of leaf spots in the field and in the session room? Why or why not?



# STUDY OF SYMPTOM DEVELOPMENT OF BACTERIAL WILT DISEASE

Wilt disease has serious influence on tomato (hot pepper, eggplant and potato) plants. This disease may be caused by other factors like fungus but the main agent is bacteria. In this activity we learn more about wilt caused by bacteria by doing some pot experiments.

## Objectives:

- Diagnose symptoms of bacterial wilt disease on tomato (hot pepper, eggplant or potato) plants
- Observe spread of bacterial wilt disease
- Discuss management practices for bacterial wilt disease

## Materials:

Field of tomato (hot pepper, eggplant or potato) plants with different diseases  
Two transparent plastic glasses per group  
Toothpicks (at least six pieces per group)  
Clean water  
Potted healthy plants (4 per group)  
Drawing paper, crayons  
Knife

## Method:

### *Part I - Extracting the Inoculant*

At the beginning of the season, each group should establish seedlings in four pots.

When disease starts to be observed in the field, visit the field and collect 3-5 infected plants per group. Carefully observe the appearance of the infected plants exhibiting symptoms of wilt disease. In the session room, set up the experiment following the steps:

1. Cut off roots and leaves of the plant. Cut the stem into pieces of 10 cm each. (*Note: Do not wash or clean the knife. This will be used to infect healthy plants in the second part of the experiment.*) Stick in three pieces of toothpicks into the stem to form a tri-pod so that the stem can be set up in the glass vertically.
2. Half fill the glass with clean water and put the stem in. About 3-5 cm of the stem should be in the water. Put the glass in a well-lighted area of the room for easier observation.
3. Observe after thirty minutes. Participants should not move the experiment so that the water is not disturbed.
4. Based on results of the experiment, i.e., when participants have established that the plant is infected by bacterial wilt disease use water to establish pot wilt disease study. (*Note: Plants infected by bacterial wilt disease will have ooze coming out of the stem and moving into the water as a white substance.*)

### *Part II - Spreading Bacterial Wilt Disease*

To set up pot studies on spread of wilt disease, use the following steps:

1. Each group should set up four pot studies to observe spread of bacterial wilt disease using the seedlings established in pots at the beginning of the season.
2. Infect healthy plants using three different methods:
  - Pot 1: Using inoculant (water) from Part I of the experiment pour water on the plant
  - Pot 2: Using inoculant (water) from Part I of the experiment, simulate infection by mechanical damage and touch damaged portions of plant with inoculant (water)
  - Pot 3: Using knife from Part I of the experiment, cut leaves and branches of plant
3. Keep another pot for control/comparison.
4. Observe results.

**Observations:**

1. Weekly draw appearance of the plant from the time that the inoculant was introduced.
2. As the infected plants start to wilt, do the diagnostic exercise to check the cause of infection (look for bacterial ooze).

**Discussions:**

Display results to whole group.

1. What were the symptoms of bacterial wilt disease in the field? How is this distinguished from symptoms caused by nutritional deficiencies or mechanical damage?
  - How do you identify the disease (what are the symptoms, where are the symptoms located)?
  - Where does the disease come from?
  - How does the disease spread?
  - How does the disease enter the plant?
2. Why did we use potted plants and not the field for the infection study?
3. Can farmers use this diagnostic test (looking for bacterial ooze) as a disease identification tool?
4. How can an identification tool (such as this) help farmers make management decisions?



**Spread**



## FACTORS THAT INFLUENCE DISEASE DEVELOPMENT - EXERCISE 1

### Introduction

As you are aware, many factors affect disease development. This includes the environment (soil, weather, wind). In this activity, we will consider various factors and see how they affect disease.

### Method:

1. Divide into five groups. Discuss and list down all factors that affect disease development.

### DISEASE: Late blight on tomato/French bean OR leaf spot on cabbage

(Use the same table for other diseases such as rust, etc.)

Factors	Favorable	Unfavorable
Fertilizer		
Weather (e.g., temperature, humidity, dew period, rain, wind)		
Microenvironment (the conditions right around the plant that could be affected by number of leaves, plant density, etc.)		
Soil conditions		
Water conditions		
Other factors		

2. For each factor and disease discuss and write down factors that are favourable and unfavourable to disease development.
3. Present results to the whole group and discuss together. As groups present, summarize results into one table.
4. Supply additional information and correct misconceptions, if necessary.

If many diseases are significant, spread the exercise over two weeks.

## FACTORS THAT INFLUENCE DISEASE DEVELOPMENT - EXERCISE 2

*(If the exercise is being done in a regular field school, the trainer should prepare the cards before the session to give farmers more time to discuss about factors that influence disease development instead of preparing the cards.)*

Last week you made a list of all factors that influence disease development. Now, we will play a card game to allow us to consider what would probably happen to disease under various conditions. Some are listed below:

- a) Weather
  - i) Temperature
  - ii) Humidity
  - iii) Dew period
  - iv) Rain
  - v) Wind
- b) Soil conditions
  - i) Intrinsic soil properties
  - ii) Fertilizer applied
- c) Microenvironment - the conditions right around the plant that could be affected by -
  - i) Number of leaves
  - ii) Plant density
  - iii) Water conditions
- d) Water conditions
  - i) Drought stress
  - ii) Flooding

### Objectives:

- List different factors that could affect disease
- Discuss how each affects disease such as blight as well as other pests of interest
- Discuss the risks of disease associated with various situations

### Materials:

Big piece of paper and pens  
Paper cut into small pieces

### Method:

1. List different factors that have an effect on disease, using the results of last week's exercise.
2. Organize the list into groups of related factors (classify by weather, micro-environment, etc.)
3. For each of the aspects, discuss how the factor affects disease. (See table below for ideas.)
4. For each factor, set various conditions.
  - a) Fertilizer
    - i) high amount of fertilizer
    - ii) medium amount of fertilizer
    - iii) low amount of fertilizer
  - b) Temperature
    - i) high
    - ii) medium
    - iii) low
  - c) Humidity
    - i) dry air
    - ii) wet air
  - d) Rain
    - i) heavy rainfall
    - ii) moderate rainfall
    - iii) drought

- e) Variety
    - i) resistant variety
    - ii) moderately resistant variety
    - iii) moderately susceptible variety
    - iv) susceptible variety
  - f) Crop stage
    - i) seedling stage
    - ii) 20-30-40 days after transplanting/sowing
    - iii) head or flower and fruit formation stage
    - iv) harvest stage
5. For each factor, each group should make a pile of cards with different conditions written on different cards.
  6. Within each small group, each person should pick a card from each pile. The combination of cards will specify the situation. Each person should describe to the group how much disease they expect to have and how they will handle the situation.

**Discussions:**

Example: If your situation is as follows, how much risk is there for a lot of disease?

- a) medium amount of fertilizer
- b) high temperature
- c) wet air
- d) moderate rainfall
- e) moderately resistant variety
- f) 20-30-40 days after transplanting/sowing

After finishing the exercise, assign certain diseases to small groups. Ask groups to make tables summarizing how different factors influence the different diseases assigned to them. For example, how high-medium-low level of fertilizer influences early blight. You can use the following table:

**Tomato: Early Blight**

Factors	How they influence disease development
Fertilizer	
Plant density	
Weather	
Etc.	

Each group should present their tables to the big group. Discuss and summarize results.



# DEMONSTRATION OF SPREAD OF DISEASES

## **Introduction**

An important aspect of disease management is sanitation. In order to prevent spread of disease, roguing is practiced or farm tools are cleaned after cultivating a field with a history of disease. Sanitation, however, is often neglected and one of the reasons may be that farmers do not understand the mechanism of spreading of diseases. This exercise demonstrates the spread of splash-dispersed (such as leaf spot disease caused by a fungus), soil-borne (such as nematodes) and insect-vectored diseases (such as a virus).

## **Objective:**

Demonstrate spreading of diseases by splashing water, soil cultivation and by insects

## **Materials:**

Field with preferably young crop (weeded)  
Watering can  
Clean poster paper  
Hoe or other soil cultivating tools  
Wheat flour or fine seeds of a fast germinating crop (e.g., watercress)  
Syringe or straw  
Five glass or plastic vials, one with strong red dye, four others with clear water

## **Method:**

### **a) Demonstration of spread of disease by splashing water**

Make sure that the soil is dry. Fill the watering can with water. Place a sheet of poster paper in between plants within a row and water the crop to simulate rain. Observe soil splash from between plant rows to the poster paper within the plant rows and explain that soil-borne diseases spread in this way.

Also, try using two plots of dry, bare soil (each about 1 X 2 m<sup>2</sup>.) Leave one plot bare and cover the other plot with mulch, e.g., rice straw, sugarcane bagasse, leaves from trees. Place sheets of poster paper along the 2m border of each plot. Water each plot and compare the soil splash on both pieces of poster paper.

### **b) Demonstration of spread of disease by soil cultivation**

Make sure that the soil is dry. Sprinkle one kg of flour on the soil between several plant rows and explain that this represents spores of a fungal disease or nematodes. In one row, ask a participant to use the hoe or other farming tool/s (wet the tool first) and simulate weeding of the field. In another row, ask the participants to wet the soles of their shoes/boots/feet and walk through the flour on their way to inspect nearby plants. Observe spread of flour. In case the field is wet, replace the flour by fine seeds and observe after germination of seeds.

### **c) Demonstration of spread of disease by insects**

Use the syringe or straw and the vials, one with strong red dye and the others with clean water. Demonstrate spread of insect-borne viruses with the syringe representing the mouth part of a sucking insect. The vial with red dye represents a virus diseased plant, the vials with clean water represent healthy plants. Draw red dye with the syringe and move to the first vial with water. Draw in some water, ejecting ('spitting') a little red dye into the vial. Observe the coloring of the water. (Healthy plant becomes infected with 'virus'.) Move to the other vials with clear water and infect them one by one. If you want to show dilution, you also have to draw in some water from each vial. Observe that the coloring of the water in the vials and the reduced inoculum in the syringe is diluted every time it is used with a 'healthy plant'.

## **Discussions:**

1. What did you observe?
2. What diseases do you know spread in this way, i.e., splash; soil; insect?

3. How might these methods of spreading disease affect crops in the field?
4. How could spread of disease be prevented?

# VIRUS AND VECTORS

## **Introduction**

One of the most difficult aspects of vegetable growing is the presence of viruses. These viruses are moved from season to season and plant to plant either by the seed itself or by insect vectors. Aphids, leafhoppers, and possibly white flies are insects that are able to transmit viruses from one plant to another. What do they have in common? Of course, they all have sucking mouth parts and enjoy feeding on several vegetables. Some viruses can be transmitted after just a few seconds of feeding (non-persistent viruses). This is more like the mouth part of the insect sucking on an infected plant and moving the virus to another healthy plant when feeding a little later on this plant. When insects transmitting this type of virus are sprayed, the insects move from plant to plant and the result can be (but not always!) that there is actually more virus than if not sprayed! The virus is acquired quickly by the insect, and the ability to transmit the virus is quickly lost.

The other type of virus requires a longer period of feeding, usually minutes to hours for the vector to get the virus to move to another plant. Probably, the virus must build up in the mouth parts of the insect so that when the insect moves to another plant there is enough inoculum to get an infection. Insects usually force saliva into the plant when beginning a hole for feeding. This outflow of saliva is sufficient to carry virus into the plant. This type of virus is called "persistent" because the insect can persistently transmit the virus to many plants after obtaining the virus from an infected plant. Virus between "non-persistent" and "persistent" are called "semi-persistent". Persistent viruses can be carried long distance by the vector because the virus is not easily lost from the vector. The vector must feed for a long time the first time to acquire the virus, and the vector must feed for a long time to be able to transmit the virus. Prevention of viruses is very difficult. The farmer has few choices but spray if he expects a lot of virus. As field observers, no good recommendation can be given due to the lack of information.

In the following activity, we will collect different types of sucking insects that can be vectors of viruses in order to observe their mouth parts. We will also demonstrate the transmittal process by using our own mouths.

## **Objectives:**

- Describe the shape and function of typical vector insects
- Use straws to demonstrate the transmittal process by vectors

## **Materials:**

Paraffin wax, heat source, magnifying glass or 10x dissecting microscope, straws, red dye

## **Method:**

### **a. Observation of mouth parts**

1. Collect aphids, leafhoppers, and white flies from the field and from other plants.
2. Bring the insects to the laboratory and kill them with alcohol.
3. Mount the insects on their back in the wax trays. This is done by partially melting the wax with a wire. Make sure the mouth parts are above the wax.
4. Observe the insects with the magnifying glass or microscope and draw their mouth parts.

### **b. Simulation of virus being transmitted by vector**

1. Set up three groups of four clear cups. Put water in each cup. In the first cup, put a drop of food colouring ("virus").
2. Dip the straw ("mouth parts") in the first cup just for a moment. Then dip into the next three cups. What happens in each of the cups? What kind of transmission does this simulate?
3. Now place some cotton in the end of the straw ("mouth parts"). First dip the straw in the "virus" and then into the next cups. Is there any difference in the results from this and the previous treatment?

4. Leave the mouth parts in the virus for a minute. Now dip the mouth parts in the other plants and leave them for a minute in each cup. What is the result? What kind of transmission does this simulate?

**Discussions:**

1. In the field, just a few insects are able to transmit virus, but often there are many virus-infected plants. Why?
2. Why control virus vectors when a large number of plants are infected with the virus? Is there a reason to control the insects? What about the economic analysis of such a situation?
3. What are the important viruses transmitted by insects in cabbage, tomato and French bean?

## SPREAD OF LEAF SPOT DISEASE BY FARMING TOOLS

(This exercise is only suitable for leaf spot diseases caused by bacteria, such as black rot on cabbage.)

### Objective:

Demonstrate the mechanical spread of leaf spot diseases by farming tools

### Materials:

Vegetable field with leaf spot incidence  
Four healthy potted young plants of a susceptible cultivar  
Scissors  
Alcohol  
Clean tap water  
Two big, plastic bags  
Labels and tape

### Method:

1. Bring the potted plants into the session room. Water the plants. Label the potted plants as follows:
  - a. Healthy control (dry)
  - b. Healthy control (wet)
  - c. Leaf spot infected (dry)
  - d. Leaf spot infected (wet)

2. Clean the scissors with alcohol. After cleaning, dip them in clean tap water. Use the scissors to cut the leaves of both 'healthy control' plants ("a" and "b"). Make incisions in different parts of several leaves as follows:

- in one leaf the main vein is cut
- in another leaf only a side vein
- in another leaf only intra-veinal cuts
- in another leaf cut along the edges of the leaf

Before each new cut, clean the scissors with alcohol and dip them in water. Cover plant "b" with the plastic bag and secure the bag with tape.

3. Visit the leaf spot infected field and collect leaves with clear leaf spot symptoms. Bring the leaves to the session room. Clean the scissors with alcohol. After cleaning, dip them in clean tap water. Use the scissors to cut once across a lesion and immediately afterwards cut a leaf of plant "c".

Before each new cut, clean the scissors and again cut across a lesion and immediately afterwards a leaf of plant "c". Make incisions in different parts of several leaves as follows:

- in one leaf the main vein is cut
- in another leaf only a side vein
- in another leaf only intra-veinal cuts
- in another leaf cut along the edges of the leaf

Before each new cut, clean the scissors with alcohol and dip them in water. Cover plant "d" with the plastic bag and secure the bag with tape.

4. Keep the potted plants in the session room and water when necessary.

### Observations:

Monitor the four plants and observe any lesions on the leaves.

### Discussions:

1. Was disease transmitted? Why or why not?
2. How would the disease spread in the field?
3. Was there a difference between the 'wet' and 'dry' treatments? If so, what does this mean?

## **STUDY OF SPREAD OF FUNGAL LEAF SPOT**

### **Objective:**

Observe the spread of a fungal disease from an infected to a healthy plant

### **Materials:**

Four **healthy** potted plants  
Leaf spot-infected leaves  
Clean water  
Small hand sprayer  
Clear plastic bags  
Tissue  
Labels

### **Method:**

1. First day preparations:  
Insert the leaf spot infected leaves in a plastic bag with moist (not soaking wet) tissue paper. Close the bag tightly but leave some air inside to avoid rotting. Leave the bag overnight.
2. Second day:  
Bring the potted plants into the classroom. Put clean tap water into the container of the small hand sprayer. Spray two potted plants with clean water. Label one plant '*healthy control, uncovered*'. Cover the other plant with a plastic bag and label the plant '*healthy control, covered*'.
3. Prepare the disease inoculum by grinding and squeezing out extract from leaves and adding this to water OR by stirring the leaf portions with leaf spots in a glass with clean water. (Note: Add sticky substance to the solution, e.g., liquid detergent, so that the spores will stick to the plant.)
4. Transfer the inoculum to the small hand sprayer.
5. Spray the inoculum on the other two potted plants.
6. Label one plant '*leaf spot infected, uncovered*'. Cover the other plant with a plastic bag so that high humidity is maintained and label that plant '*leaf spot infected, covered*'.
7. Clean the hand sprayer carefully after use.
8. The plastic should not be removed, except for observations or watering of the plants.
9. On all four pots, spray water 6 – 8 times per day to create the environment for disease development.

### **Observations:**

1. Observe the development of symptoms in both pots over time.
2. Once the symptoms have been observed sufficiently, destroy the infected plants to avoid infection of other plants.

### **Discussions:**

1. Why did we inoculate the plants inside the session room and not in the field?
2. Why did we set up covered and uncovered treatments?
3. How many days did it take before symptoms were visible?
4. How does a fungal leaf spot spread in a field?

# **STUDY OF SYMPTOM DEVELOPMENT OF LEAF SPOT: EARLY BLIGHT ON CABBAGE; LATE BLIGHT ON TOMATO AND FRENCH BEAN**

## **Objective:**

Diagnose symptoms of leaf spot (cabbage) and late blight (tomato and French bean) diseases

## **Materials:**

Young cabbage leaves with small leaf spots; tomato and French bean leaves with 'suspected' brown spots  
Petri dishes, jars, tissue paper, cotton  
Labels, tags  
Drawing paper, crayons, ruler, hand lens

## **Method 1: For cabbage**

### ***In the field:***

1. Leaf spots are usually found on the older leaves of the plant. Select a plant with leaf spots in various sizes. Make sure the leaf is not yet yellowing.
2. Mark this plant with a pole and tag one or two leaves on the plant with small and medium sized leaf spots. You can also draw a big circle around a few spots.
3. Take a few leaves with small and medium sized leaf spots from another plant and bring these to the session room.

### ***In the session room:***

1. Cut two leaf portions with small leaf spots into a disc. Mark a leaf spot on each disc with a marker. Place one of the discs in a petri dish with dry tissue paper ("dry") and the other in a petri dish with wet tissue paper ("wet"). Close with the lid.
2. Place leaf with a marked, small leaf spot in a plastic bag with dry tissue paper.
3. Place leaf with a marked, small leaf spot in a jar with water (+sugar) ("dry")
4. Place leaf with a marked, small leaf spot in a jar with water (+ sugar) and cover with a big transparent plastic bag ("wet").

## **Method 2: For tomato and French bean**

### ***In the field:***

1. Late blight symptoms can be found on leaves of all ages as well as on stems and on the fruits. Select a plant with brown symptoms on the leaves. Make sure the leaf is not yet yellowing.
2. Mark this plant with a pole and tag one or two leaves on the plant with small and medium size brown lesions.
3. Take a few leaves with small and medium size lesions from another plant and bring these to the session room.

### ***In the session room:***

1. Take two single leaves with blight symptoms.
2. Place one leaf in a jar with dry tissue paper (mark as 'Dry') and the other in a jar with wet tissue paper (mark as 'Wet').

## **Observations:**

1. Draw each leaf spot and the area around the spot in detail, using colour crayons.
2. Measure the diameter of the leaf spot.
3. Indicate whether the leaf spot is sporulating or not.
4. Monitor the leaf spot over time (e.g. after two, four and six days) and regularly draw and measure the size of the leaf spot (field and classroom experiment).

## **Discussions:**

1. What happens with a leaf spot/lesion over time (colour, structure, area around spot)?

2. What is the effect of humidity on the symptom development of leaf spot/blight diseases ("dry" versus "wet" conditions)?
3. How can you recognize the first signs or beginning of a leaf spot/lesion?
4. How long did it take before spores were visible? What is the size of a spot that carries spores?
5. What conditions in the field will be favourable for disease development?
6. What was the difference in growth between the leaf spots/blight lesions in the field and the ones in the jars? What caused these differences?
7. What can you conclude about spots/lesions that do not grow in time? Can they be caused by something other than leaf spot/blight disease?
8. For the management of blight in tomato and French bean, is it important to know whether the blight is caused by *Alternaria* (early blight) or by *Phytophthora* (late blight). Why or why not?



## **POT EXPERIMENT TO TEST WHETHER ROOT DISEASES ARE SOIL BORNE**

### **Objective:**

Demonstrate disease development of healthy plant material in contaminated soil

### **Materials:**

Seeds of the selected vegetable crop (susceptible cultivar)

Four or more large pots

Clean soil (e.g., from a wetland paddy field)

Labels

### **Method:**

Fill four pots with clean soil. Collect diseased plants and cut up the roots into many small parts and mix with the soil in two pots. Label the pots "*infected soil*". Label the two other pots "*healthy soil*". Sow seeds in each pot. Water the plants regularly and keep them in a shady place (if necessary under a screen cage to keep insects out) until symptoms appear. Apply a little fertilizer, if needed. Observe plant development in the two treatments over time.

### **Discussions:**

1. Why did we use potted plants and not a field for the infection study?
2. How many weeks did it take before symptoms became visible?
3. Estimate the yield loss in the field using the rate of infection in the pot experiment.
4. How does the disease spread in a field?

## **TEST OF TOMATO SEED QUALITY**

### **Introduction**

The use of clean seed is essential to control diseases. To separate light-weighting, possibly disease infected seeds from healthy seeds, a separation test with water is used. The following exercise will show whether light-weighting seeds have a lower germination capacity and whether discoloration or fungal growth upon germination can be seen.

### **Objective:**

Test seed lots for germination capacity and infection with seed-borne diseases

### **Materials:**

Tomato seeds  
Tissue paper  
Clear or black plastic bags  
Clean water  
Hand lens

### **Method:**

1. Take a sample from the seed lot.
2. Prepare a container with water. Put the seeds in the water container.
3. Stir the seeds. Allow one or two minutes for the seeds to settle.
4. After settling, carefully remove the floating seeds. Put these in a container labelled as “floating seeds”.
5. Also collect the remaining seeds and label them as “sinking seeds”. Count 100 seeds of each seed lot.

### **For each seed lot:**

1. Prepare two layers of tissue paper and carefully sprinkle clean water on the tissue. The tissue should be moist but not soaking wet.
2. Position the 100 seeds on the tissue paper in ten rows of ten seeds with a distance between seeds of about 3 cm. The seeds will stick on the moist tissue.
3. Cover the seeds with another layer of tissue paper and also slightly moisten the top tissue layer with clean water.
4. Loosely roll up the tissue with the seeds inside into a ‘sausage’.
5. Put the roll into the plastic bag to keep it moist.
6. Close the bag but leave some air inside.
7. Label the bag either “floating seeds” or “sinking seeds”, according to the seed lot inside.
8. Keep the bags in a dark place.

### **Observations:**

1. Daily observations on germination and growth of mold can start after one or two days.
2. After each observation, note the number of germinated seeds and the number of seeds with mold growth (hairy fungal structures) or rot. Use the hand lens to check each seed carefully.
3. After each observation, check the moisture of the tissue. If dry, sprinkle some more water on the tissue. Do not remove the seeds.
4. Again, roll up the tissue and put back into the plastic bag for further (daily) observations.
5. After seven days, if possible, measure root length on the germinated seeds.
6. After one week, or longer if desired, results can be summarized in a bar graph (horizontal: days after ‘sowing’; vertical: cumulative % germination and cumulative % diseased seeds) on poster paper and presented per group.

### **Discussions:**

1. Was there a difference in germination between the treatments?
2. Was there a difference in the number of seeds with mold growth or rot between treatments?
3. What would happen with the seeds of each lot in a seed bed?
4. Why should the use of diseased seeds be avoided?

## **EFFECTS OF INUNDATION OF FIELDS ON INCIDENCE OF WILT DISEASES**

### **Objective:**

Demonstrate the reduction of soil-borne wilting diseases by rotation with paddy rice

### **Materials:**

Dryland soil from a field continuously planted with vegetables with a history of wilting disease

Wetland soil (of a similar soil type as the dryland soil) from a paddy rice field (preferably one that has been flooded with water for two to three months)

Vegetable seeds of the studied crop

### **Method:**

Prepare one seedbed in the field with soil that has been continuously planted with vegetables. Label this as '*dryland soil*'. Take soil from the paddy rice field and prepare another seedbed using the paddy soil. Label this as '*wetland soil*'. Sow (drill) 100 seeds in rows in each seedbed using a space of at least 5cm between each seed.

### **Discussions:**

1. What are the differences between the two treatments?
2. Did wilting occur? If yes, was there a difference in wilting incidence between both treatments? Why?
3. Would it be possible for farmers to prepare seedbeds with wetland soil? What would be the advantages and what would be the disadvantages?
4. What is the importance of crop rotation on incidence of wilt diseases?

# Management



# DISEASE MANAGEMENT

## **Introduction**

Diseases are an important part of crop protection, but are usually very difficult to understand in the field. This is partly because the causal organisms (bacteria, fungi, viruses) are very small and cannot be seen moving around like insects or rats. We must learn about these organisms to manage diseases better.

Management includes prevention and slowing down epidemics. Diseases will never be completely eradicated - only populations reduced to very low levels. Management usually needs the cooperation of several farmers working together to reduce overall disease in an area.

What are management activities? Below are some activities.

1. Allowing only disease-free seed and planting materials into an area. This can be done at any level of organization: farmer group, village, district, province, national.
2. Careful purchase of materials in the market and plant sellers.
3. Selecting good varieties.
4. Sanitation is important for keeping inoculum from one crop to get into the next crop. For example, potato blight (*Phytophthora infestans*) can be reduced by removing excess and old potatoes from the field.
5. Destroy sources of inoculum such as material in nurseries and fields with diseases. For large-scale removal, it is useful to have funding to compensate farmers for destruction of sources of inoculum (fruit trees, planted seasonal crops).
6. It is also important to keep nematode infested soil from moving from field to field on the shoes of farmers, on buffalos, and plows.
7. Deep burial of diseased plant materials by plowing, removal of diseased plants, and repeated plowing to expose the soil to sunlight
8. Proper fertilizer management. There are numerous examples in which addition of nitrogen, potassium or calcium actually reduces the effects of certain fungi.
9. Small areas planted to a particular crop before the main growing season for the crop should be avoided. These small areas build up inoculum that is then carried over to the main season.
10. Crop rotation with crops that are not infected by the same diseases.
11. Crop planting times should take into consideration dominant diseases in the area and the effect of the micro-climate.
12. Using appropriate planting densities.

Some of these activities are related to the management of disease by effecting some changes in the environment. Some have to do with the plant and others have to do with effecting changes in the disease organism or pathogen. In this activity, we will use a method called brainstorming to develop area-wide management methods and activities. The process is as important as the content since management implies participation of many persons.

## **Objectives:**

- Outline management activities that could be organized for an area to reduce disease incidence
- Use brain-storming techniques to develop inputs from all participants

## **Materials:**

Big paper and markers

## **Method:**

(Brainstorming is a method of getting lots of creative ideas. Many ideas will not be useful, but the ideas will act as seeds to other ideas. Discussion of ideas is allowed only after all ideas have been written down)

1. Assign one person as the secretary who will write on the large piece of paper. Do not use a small piece because the whole group should be able to read the paper. Assign another person to be the facilitator.
2. The secretary should write "Area-wide Disease Management" on the top of a large piece of paper.

3. The facilitator should ask the group what disease management methods are practiced by farmers in their localities.
4. The group members should tell the secretary their ideas. The secretary will write down the ideas. Other members are not allowed to make comments at this point. If any member makes comments, the Facilitator must ask the person to be quiet.
5. Continue writing down ideas without discussions until the first page is full.
6. After the page is full, discuss each idea beginning from the top of the list. The Facilitator should be sure each person gives some comments. The Secretary should summarize the discussions about each point. Write the summaries on another large piece of paper. The summary should be along the angles of the disease triangle, i.e., some activities are related to the management of disease by effecting some changes in the environment; some have to do with the plant and others have to do with effecting changes in the disease organism or pathogen.
7. If there is time, use the same process to answer the following question: "What can IPM trainers do to help manage diseases in our village?"

## DISEASE TRIANGLE TO EXPLAIN DISEASE MANAGEMENT

### Introduction

Results of earlier exercises may form the basis for a discussion on disease management. It shows that diseases only become problematic when the interaction between pathogen, crop and environment is optimal for the pathogen. This exercise calls attention to the fact that disease management basically consists of orchestrating the pathogen, crop and/or environment.

### Objectives:

- Reinforce discussions on disease management
- List down management practices for each component of the disease triangle to 'inactivate' disease spread

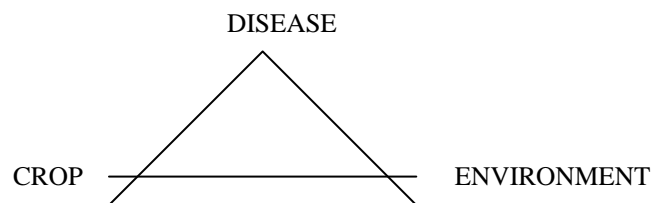
### Materials:

Big paper, pens, markers

### Method:

1. Ask participants to recall the earlier discussion on disease management, i.e., that changes may be effected on the environment, plant or the pathogen to prevent disease. Also that for the development of disease, these three factors must be present or favourable.
2. Ask for volunteers to give examples. For instance, a fungal disease that survives on crop residues in soil (Is the disease present? -> Yes) will definitely show when a susceptible crop (Is a susceptible crop present? -> Yes) is planted in a rainy season (Is a suitable environment present? -> Yes).

Draw the disease triangle:



### Discussions:

Discussions may focus on the fact that the disease triangle helps us understand management practices that may be tried out or avoided to 'inactivate' at least one of the angles in the triangle. The following examples may be used to start a discussion on practical implementation of disease management strategies.

#### Disease angle (Is the disease present?):

1. To avoid a soil-borne disease, one could test the use of sub-soil in the nursery (Is the disease present? -> No? -> How would you apply this method in the field?).
2. To avoid an insect-transmitted virus disease, one could try to cover a nursery with screen-netting (Is the disease present? -> No? -> How would you apply this method in the field?).
3. A season with paddy rice can be considered as a season of inundation of soil with water. Certain soil-borne diseases are killed when soil is flooded for a period of time (Is the disease present? -> No? -> How would you apply this method in the field?).
4. By implementing sanitation measures such as removal of infected crop residues or diseased plant material in the field, one can test whether removal of sources of infection reduces disease (Is the disease present? -> No? -> How would you apply this method in the field?).

#### Crop angle (Is a susceptible crop present?):

1. Search for resistant cultivars by planting a portion of the field with other cultivars from neighboring areas and/or imported cultivars (Is the crop present? -> No? -> How would you apply this method in the field?).



2. Crop rotation by avoiding planting susceptible crops for several cropping seasons (Is the crop present? -> No? -> How would you apply this method in the field?).
3. Weeding of susceptible weeds (Is the crop present? -> No? -> How would you apply this method in the field?).

**Environment angle (Is a suitable environment present?):**

1. Choose a season that is not favorable for disease, e.g., the dry season (Is the environment favorable? -> No? -> How would you apply this method in the field?).
2. Change from overhead irrigation to flooding to reduce leaf wetness (Is the environment favorable? -> No? -> How would you apply this method in the field?).
3. Test mixed cropping so that the disease cannot spread easily (Is the environment favorable? -> No? -> How would you apply this method in the field?).

After the discussion, divide the group into four. Refer to the session on disease/symptom groups. Assign one disease group to each group of participants. Ask each group to select one disease for a crop and to design a management measure that can be tested in the TOT field. Ask groups to present after when they have completed the task. Discuss which angle of the disease triangle is avoided or inactivated. Try to implement the management measures that the groups present.

## **MANAGEMENT OF DIFFERENT DISEASE GROUPS**

### **Objectives:**

- Identify different methods to manage diseases in the field
- Discuss how the methods can be applied for each of the disease groups in the field

### **Materials:**

Big paper, pens, markers

### **Method:**

1. With the whole group, first make a list of all possible methods that can be used to manage and control diseases in the field.
2. Then each group selects one disease. For each disease groups should discuss how they can use each of the possible management methods that they listed. Whether certain methods can be used or not, depends very much on how a disease develops in the field.
3. For the disease that your group selected discuss the questions in the following section.

### **Discussions:**

1. How do you identify the disease (what are the symptoms, where are the symptoms located)?
2. Where does the disease come from?
3. How does the disease spread?
4. How does the disease enter the plant?
5. What development stages of the disease can you identify?
6. What factors stimulate or inhibit development of the disease?
7. What damage does it do to yield or quality of the crop (why, how)?
8. What other information do you need to make a decision on management/control of the disease?
9. How can you obtain/discover this additional information in your own field?
10. What can you do with this information? How does it help you to make a better management decision?

Summarize the results of your discussion on a big piece of paper. Each group will present the findings of their group.



# **Beneficials**



## BENEFICIALS AMONG THE DISEASE GROUPS

### **Introduction**

Often, farmers and trainers are not aware of the beneficials among the disease groups, i.e., that roughly out of ten fungi, bacteria, viruses and nematodes species only one specie attacks cultivated crops! The following exercise may be used in order to highlight the importance of biological control agents among the diseases and to become aware of the negative impact of pesticides on beneficials among the disease groups.

### **Objective:**

Discuss about beneficials ('natural enemies') among the disease groups

### **Materials:**

Big paper, pens, markers

If available, specimen of beneficials from the field

### **Method:**

Collect examples of beneficials from the field. (Beneficials that attack pest insects are recognized more easily than beneficials that affect disease agents because of the size of the target organism.)

For example:

- Insect pathogens and antagonists (beneficial fungi)
- *Bacillus thuringiensis* or antagonists (beneficial bacteria)
- NPV or predisposition by viruses (beneficial viruses)
- Nematodes that infect and kill insects or compete with other nematodes (beneficial nematodes)

**NOTE:** *Beneficial fungi attacking aphids or caterpillars can often be seen during rainy seasons. Symptoms of fungal infections on aphids or caterpillars consist of mouldy structures that cover the insects. Fungus infected insects usually look like dried mummies, covered with mycelium that may or may not be sporulating. Bacterial infections of caterpillars usually cause larvae to stop eating, become limp and shrunken, die and decompose. The body color often turns brownish-black or red-yellow. When caterpillars are infected with beneficial viruses, their behavior changes. After death the caterpillars often hang as limp, half-waterish, decomposing sacs down from (often upper) leaves. Beneficial nematodes mostly attack soil-dwelling insects. Infected insects become orange, yellow, brown or red in color and often swell up.*

### **Discussions:**

1. What beneficials were collected from the field?
2. What are the possible negative effects of pesticides (insecticides and fungicides) on beneficials?
3. What do you think of the following statements:
  - *Only insecticides are bad for friends of farmers in the field*
  - *Any chemical substance (pesticides and fertilizer) can be harmful to beneficials.*

**Weather**





## WEATHER

### *General introduction and Effect on diseases*

Climate and weather are important for the growth and development of diseases, insects, natural enemies and plants. Climate is the long-term general pattern of the daily weather patterns. For example, the climate of southern Vietnam is hotter than the climate of northern Vietnam. On a particular day however, the weather in northern Vietnam may be hotter than southern Vietnam. The weather is difficult to predict, while climate is easier to forecast. In fact, weather scientists cannot reliably predict the weather for more than about 24 hours, even with super computers and vast information networks. The weather of yesterday and today are still the best predictors of the weather tomorrow.

Weather is very important for determining the development and growth of disease and insects. It is not surprising then that diseases and insects are also very difficult to predict. Prediction is even more difficult because the short-term pattern of weather is also important (e.g., four rainy days versus one day rain - two days cold - one day rain) but impossible to predict. Besides our lack of prediction ability, scientists do not know the actual effect of certain weather patterns on the development of disease.

Weather can be measured. Temperature ( $^{\circ}\text{C}$  and degree days), rainfall (mm/hour or mm/day), solar radiation (joules/cm<sup>2</sup>/day), hours of cloud cover, relative humidity (%), atmospheric pressure (mbar), wind speed (m/minute), wind direction, and day-length (hours) are some of the parameters that are used to define and measure the weather. "It is a hot and windy day" can be described as "The maximum temperature is 35 $^{\circ}\text{C}$ , wind direction south-east blowing at five meters per minute, with cloud cover after 3 p.m."

So what are the important concepts when considering the effect of weather on living organisms? First is the rate of chemical reactions inside organisms. For most chemical reactions the hotter the chemical, the faster the reaction. Thus rice cooks faster on a hot fire, than on a warm fire. Plants, insects, spiders, bacteria, fungi and viruses also "cook" faster, meaning they develop faster. Crops mature a couple of days faster in hot areas. Insects develop from egg to adults in shorter times in hot areas. Fungi grow more quickly on food left on the table than food placed in the refrigerator. However, every organism has an optimal temperature for best growth and development. Temperature that is too hot kills plants and insects, etc. Some plants grow better at 25 $^{\circ}\text{C}$  than at 30 $^{\circ}\text{C}$ , because the plants have an optimum growth temperature (actually the plant's enzymes have an optimal reaction temperature). This is true for insects and disease organisms. This explains why different plants, insects and diseases are found on mountain-tops than at low elevations. Mammals are able to regulate body temperature so that we are less affected by outside temperature changes.

Temperature can be accumulated. This is called degree-day. Thus one day at 25 degrees may be the same as two days at 10 degrees, depending on the growth rate of the organism at different temperature. Degree-days are used in forecasting models to predict the development rate of insects and diseases in different environments.

Another key concept is water. Water is important for all life. Water can be in the form of water on a surface that is important for roots, for insects, and for germination of disease organisms. Water is also in the air as moisture. Low moisture (low humidity) means the air is dry. High humidity means there is a lot of water in the air. However, the amount of water that can be held in the air depends on how hot the air is. The hotter the air, the more moisture can be held. A cold glass collects water on the outside because the air around the cold glass becomes cold, and moisture in the air becomes water on the glass. Humidity is important for the development of micro-organisms, especially bacteria and fungi.

## EFFECT ON DISEASE ORGANISMS

### **Introduction**

Disease organisms for plants include bacteria, fungi, virus, and sometimes nematodes (some plant pathologists don't consider nematodes as 'disease' - in the field it doesn't really matter). Weather can affect the processes of the disease cycle in the following ways:

*Transport/movement:* Disease organisms are moved by the wind, by splashing rain water, and by flowing or flooding rain water moving soil, plants and disease organisms. The level of humidity, temperature and solar isolation determine the survival of the disease organisms during movement and before a host is available for infection.

*Germination:* Is mostly determined by the availability of an appropriate host. However, the ability to germinate is sometimes determined by temperature, humidity, water on the surface after rain or night dew, and solar radiation. The germination of fungi and bacteria is the first step in infection and usually means that a part of the disease organism is developing for entering an opening in the plant tissue or making an opening.

*Infection:* Success and failure of infection may depend on the growth rate of the disease organism in relation to the defense rate of the host plant. Success of infection is determined more by the plant condition than by the disease organism.

*Incubation:* Incubation is the time required for an infection to cause symptoms. The development of symptoms is also a function of the plant type and condition, but also a function of the relative development rates of the plant and the disease. Disease is like a race between the plant and the disease organism. If the weather is better for the plant than for the disease (in terms of optimum temperature, water, sunlight, etc.) the plant may never show symptoms or only show minor symptoms. However, if weather conditions are best for the disease organism, the disease may quickly have symptoms, quickly develop inoculum that is ready to be moved to other leaves or plants.

*Inoculum development/reproduction:* Production of fruiting bodies can be a function of temperature, sunlight and relative humidity. Movement of inoculum returns us to beginning of disease cycle.

In this activity we will note the specific effect of weather on the disease cycle process for the major diseases of vegetables.

### **Objective:**

Describe the effect of weather on the disease cycle processes for at least one major vegetable disease

### **Materials:**

Big paper, markers

### **Method:**

1. Choose a major disease on the vegetables you are studying (caused by bacteria, fungi, virus or nematodes).
2. On a large piece of paper, make two columns. On the top left column write "disease process" and list the disease cycle process in the left column.
3. On the top of the right column, write "Effect of disease" and write the name of the selected disease. In the column, write the effect of weather for each of the disease cycle processes. For example: Transport/Movement - Wind moves rust fungi from leaf to leaf, plant to plant, and field to field.
4. Present your opinions to the group.

## *Weather*

## EFFECT ON INSECTS

### **Introduction**

Weather is important for determining the growth and development of diseases, insects and plants. In the introduction we explored the effect of weather on diseases. Our main ideas were that diseases are bags of chemical that react to temperature and water. The effect on the plant and the health and variety of the plant determine the development of disease symptoms.

Insects can also be considered bags of chemicals whose growth and development is determined by temperature and humidity. Temperature of course must be measured at the place where the insect is living. This means an insect on the leaf surface in the hot sun is growing faster than the same species hiding in the cool soil. The development of an insect species in a cool environment will be slower than the same insect species in a hot environment. Of course, there is also an optimal temperature for growth.

What other factors determine insect growth and development, especially as populations? One is the wind. Wind currents move insects from one area to another. Most insects can only stay in the air and let the wind push them about. The wind is also important for carrying the scent of host plants, or females of the same species. Plant scents allow insects to find their host plant. Some natural enemies also use the plant scent to find their prey when the prey is usually on a particular type of host plant (for example the parasite of diamondback moth that only occurs on cabbage). The scent of female insects carried by the wind allows males to find their mates.

Rain is another important part of the weather that strongly influences insects. Direct kill of insects by rain is important for small insects. (Why do most insects feed on the bottom of leaves?) Moisture is important for ending aestivation ("sleeping") stages of some larvae/pupae that survive in soil or plants during the dry season. Rain after a dry period causes some kinds of nitrogen to be more available to the plants so that the plants suddenly become more green and active in growth. This is an indirect positive influence on insect population growth.

The weather influences the growth of insects in many ways. In this activity, we will discuss and develop a list of ways not listed above.

### **Objective:**

Describe the effect of weather on the growth and development of insect populations

### **Materials:**

Big paper, markers, ruler

### **Method:**

1. On a large piece of paper, make two columns. On the top of the left column write "Insect development process" and list the following processes in the column:
  - Migration (long distance)
  - Movement (short distance)
  - Birth rate
  - Death rate
  - Development rate (egg to adult stages)
  - Aestivation
2. On the top of the right column, write "Effect of Weather". Make a list of weather influences on each parameter of population development in the left column. Try to give an example for each item.
3. Try to make a "Big Picture" of population development in relation to the development of the crop. For example, what would be the difference if the weather were hotter, or wetter, or dryer, or colder? Discuss the difference. What have been your experiences?
4. Present your results to the group.

*Weather*

# WEATHER, INSECTS AND PATHOGENS

## Measuring the Micro-habitat

### *Introduction*

We discussed the influence of weather on organisms in the first sections on weather, insects and diseases. We said insects (and diseases) were like "bags of chemicals" with optimal reaction to temperatures, humidity and moisture. What happens in the field? Are there major differences in temperature, and moisture on a small scale (several hectares)?

Differences in weather are usually seen over large areas. We will explore different sites and measure the micro-habitat. We will look at both temperature and moisture over several hectares on fields around the Training Center. Micro-climates often are different because of exposure to sunshine or rain. The micro-climate will change when moving from place to place and moving through time in the same place. Remember that an insect or pathogen moves its place when going from the top of a leaf to the bottom of the leaf. Small changes for us, are tremendous changes for insects or pathogens moving with the wind, rain, or by themselves.

### **Objective:**

Show that weather parameters (temperature and moisture) are different over small areas of several meters

### **Materials:**

Big paper, pencil  
Thermometers (2 per group), plastic bags, scales

### **Method:**

1. Choosing sites: choose two locations. The locations should be in the following places:
  - a. place with no shade and high on a slope
  - b. place with lots of shade and high on a slope
  - c. place with no shade and low on a slope
  - d. place with lots of shade and low on a slope
2. Soil moisture: at each site, place some soil in a plastic bag. One handful is enough. Close the bag. Weigh the content of the bag. Dry the soil in the sun. Weigh the soil with the bag again after drying. The difference in weight is the amount of water in the soil. The original soil weight was the weight of water plus the non-water portion. {Original % moisture = [(weight of water)/(original weight - water weight)] x 100}.
3. Temperature: use the thermometer to measure three positions for each site:
  - a. soil temperature
  - b. air temperature above a plant
  - c. air temperature at the bottom of the plant
4. Make a table of temperatures and soil moisture for the sites.
5. Can you explain why there are differences in soil moisture at each site? Remember recent rains, irrigation, etc. Are these differences important for the growth and development of insects and diseases? Especially in terms of the soil organisms!
6. What are the differences in temperatures? How do you think these values will change over a one-day period? Make a hypothetical graph of these changes. Are these temperature differences important for insect and disease development?
7. Is there an interaction between temperature and moisture for any site? What is the interaction?
8. Can you give examples from your own experience where disease and insects seem to be more dense or less dense because of differences in the micro-climate or micro-habitat? Why do some insects stay at the bottom of the rice plant? some insects at the top?

## **WEATHER AND PLANTS**

### ***Introduction***

We have discussed the effect of weather on the important processes of insect development (individuals and populations) and the effect of weather on the important processes on disease development. We began by making a general model of development for insects (egg - larvae/pupae - adult) and diseases (germination - infection - incubation - reproduction and movement). Next we considered the effect of weather (temperature, rain, humidity, solar radiation, etc.) on each of the general processes.

Why did we work this way? First is that we must learn to take big problems and break them into smaller problems. This is a problem solving method and very important for considering complex problems and interactions. Second is the importance of generalizing. You have all learned much specific information but you must be able to put this information into a general framework that relates to other problems.

Now to the main topic. These exercises are getting longer, but hopefully you are getting the skills and concepts.

In this activity we will look at the important stages of plant growth and development and discuss the influence of weather.

### ***Plant stages (in general)***

1. Transport of seeds or vegetative parts. This is especially important for weeds and other wild plants.
2. Germination
3. Vegetative phase. This is the important stage for building a foundation for the reproductive stage. More flowers and fruits will be produced when more starch is stored in the plant (how does the plant make starch?). Think about the vegetative phase as the population of stems, leaves and roots in the field. This is something like the larvae/pupae of insects.
4. Flowers. These are important organs on a plant. For determinant plants the flowers are produced only for a short period and are therefore very sensitive to harsh changes in weather. Think about these as the population of reproductive parts. This is something like female adults in insect populations.
5. Maturation of seed. Seeds must be produced and matured to be viable for the next growth. This is similar to populations of eggs produced by adult insects (fecundity).

In this activity consider the influence of weather on each stage. Use a systematic approach. Give examples. Break the big problem to smaller problems that can be discussed.

### **Objective:**

Systematically explain the effect of weather on plant development

### **Materials:**

Big paper, markers

### **Method:**

1. On the piece of paper, make three columns. Label one column "Plant development". Label the second column "Weather parameter" and the third column "Effect of weather".
2. Discuss and fill in the chart. Give examples from different crops and weeds.
3. Each group should then give a systematic explanation of the effects of weather on plants to the other groups.





# **Soils and Nutrients**



## WATER INFILTRATION RATES

Adapted from Richard Sikora's Soil Nutrients and Soil Health in Lowland Rice Production

### **Introduction**

The water content of the soil is as much an important biological indicator of the soil condition as its soil respiration. Soil respiration allows microorganisms to perform their function of breaking down organic material that the plant can use for its development. Knowing more about the type of soil a farmer has in his field will help him make decisions about how he can improve it for his benefit.

### **Objectives:**

- Observe the water holding capacity of different types of soil
- Discuss how to improve water holding capacity and its importance to overall plant health

### **Materials:**

Soil samples from two areas mentioned in possible treatments under *Method*

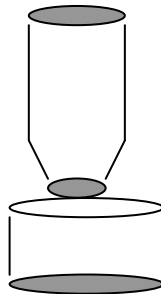
Plastic bottles approximately 1 liter size (two per group), pieces of cloth, beakers

### **Method:**

1. Each group should set up two treatments each as follows:
  - Control (soil)
  - Soil + decomposed organic matter.
2. Take a used plastic bottle of approximately 1 liter size and cut the bottom off. Prepare two bottles per group for the treatments.
3. Put the bottle upside down and cover the bottle opening that is now at the bottom with a sheet of cloth.
4. Following the treatments, fill bottles with 1 kg air-dried soil to serve as a column. The column should now be brought into right position (see drawing) and a beaker is placed under the column to collect excessive water released by the column.
5. Finally pour slowly a predetermined volume of water (i.e. 500 ml) on the surface of the column and let the soil soak up the water.
6. Add more water until the predetermined amount of water is used up.
7. By subtracting the amount of water released by the column from the total amount of water you will get the water holding capacity.

### **Discussions:**

1. Calculate the water holding capacity of each treatment.
2. Explain the importance of the soil's water holding capacity to the overall plant health.
3. How can the soil's water holding capacity be improved?



## EXISTENCE OF MICROORGANISMS

Adapted from Richard Sikora's Soil Nutrients and Soil Health in Lowland Rice Production

### **Introduction**

Dead organic material of plant and animal origin will primarily be broken down by soil organisms, especially microorganisms. The end product of these biological processes is called humus and is an important factor for soil fertility. However, this is difficult for farmers to understand because farmers do not see the microorganisms.

### **Objectives:**

- Visualize microbial growth
- Discuss the importance of microorganisms to soil fertility and to overall plant health

### **Materials:**

50 g boiled rice  
100 ml polyethylene bag  
Steamer  
Inoculum (bacterial wilt of tomato or potato)  
Soil microbial solution (see process of preparation under *Method*)

### **Method:**

1. Prepare the nutrient medium for the microbial. Each group should prepare three bags for three treatments. To do this, put 50 g boiled rice into a 100 ml polyethylene bag and seal it. Within 24 hours, for 20 minutes each sterilize the bag (nutrient medium) twice by steam-heating. After cooling down the white sterile medium is ready to use.
2. Set up three treatments by applying microorganisms from the following sources:
  - a) a drop of *Pseudomonas solanacearum* (bacterial wilt of tomato or potato). This is done by extracting inoculum from diseased plants
  - b) soil microbial solution. This is done by first mixing 50 g of field soil with 50 ml tap water. Stir the suspension and then let the soil settle for 10 minutes. Take 10 ml of the supernatant and pour on the sterile rice medium.
  - c) control. This is done by putting some soil supernatant in a bottle and heating it by steam for 20 minutes as described before. No microbial growth is expected in the control treatment.
3. To demonstrate microbial growth the plastic bags containing sterile rice are carefully opened and the inoculum is spread on the rice medium surface. The bags are closed again and let to sit in room temperature for approximately 7 days.
4. Microbial growth will become visible on the rice medium surface within 24 hours. A slimy lawn of various colors indicates bacterial growth whereas fungi appear to produce dry mycelia growing in the air best describable as a layer of fine cotton fibers.

### **Discussions:**

1. Describe observations from the three treatments.
2. Where did the growth come from?
3. What effect would these microorganisms have on the soil? On crop development? Why?

## **ORGANIC CONTENT OF LOCAL SOILS**

Adapted from Richard Sikora's Soil Nutrients and Soil Health in Lowland Rice Production

### ***Introduction***

Intensive farming practices which includes excessive chemical fertilizer and pesticide application, among others has brought with it a rapid decline in soil organic matter. The situation makes the crop susceptible to biotic and abiotic stress factors that leads farmers to continue increasing chemical inputs. Recent information on how to address this issue has called attention to the benefits that may be gained from restoring the organic matter in the soil especially when practiced with integrated pest and nutrient management. This exercise will allow farmers and trainers to gain ideas about why healthy soil means healthy crop.

### ***Objectives:***

- Observe the amount of organic matter present in the soil
- Discuss the importance of soil organic content to overall plant health

### ***Materials:***

Five areas to take samples from; identify areas where different soil amendments were used as mentioned in possible treatments under *Method*

Buckets, plastic foil, shovels, weighing scales

### ***Method:***

1. Identify areas different soil amendments were used. Possible treatments include:
  - Control (non amended soil)
  - Soil amended with straw
  - Soil amended with straw and urea
  - Soil amended with straw and compost
  - Soil amended with compost
2. Assign each group to a different area.
3. Each group should sample from the field of interest half a bucket of soil (approximately 5 kg).
4. Spread soil sample on a plastic foil and air-dry the soil in the sun.
5. Break clumps to get a homogeneous fine material.
6. Weigh 1 kg dried soil for the experiment.
7. Fill a bucket three-quarters with tap water. Stir the soil thoroughly.
8. Collect the organic matter from the water surface and air-dry it. (Organic matter is lighter than water and will accumulate on the water surface.)
9. Let the remaining soil settle to the bottom of the bucket for approximately ten minutes and carefully decant the water.
10. Air-dry the soil and take the dry weight of soil and organic matter separately.
11. Calculate percentage of organic matter based on total soil dry weight.

### ***Discussions:***

4. Which of the treatments had more organic matter content? Why do you think it was such?
5. Explain why healthy soil means healthy crop.

## COMPOSTING

*(The trainer with some farmers may prepare the compost at least a month before the season for use in the study fields. This activity is to introduce the concept of “proper” composting and walk farmers through the steps involved in preparing compost as part of the regular field school/study season. Full-season follow-up activities on soils and fertilizer management will have a more detailed curriculum including different field studies and exercises.)*

### **Introduction**

Organic fertilizers improve the soil structure that is important in sustained farming. Furthermore, organic fertilizers contain micro-elements that crops need in addition to NPK. In Vietnam, some materials that are commonly used for organic fertilizers are water hyacinth, leaves of plants from the bean family, ash from rice straw, animal as well as human manure. Composting is a process that can be used to hasten the process of decomposition of the materials, either from plants or animals, so that the organic fertilizer is available when the farmer needs to use it in his field. (Many different materials are used for composting depending on the locality. What is important is that it makes use of materials that are available and at the least cost.)

In Vietnam, farmers practice either the “hot” or the “cold” method for preparing compost. “Cold” compost is prepared in a pit in the ground; “hot” compost is normally prepared above the ground. Each method has its own advantages and disadvantages. The “cold” process of composting is an anaerobic process. Due to the lack of oxygen, microorganisms are not able to “burn” (oxidize) the organic matter and therefore the temperature of the organic matter does not increase (hence the term “cold” composting). However, the result is a rotting process which does not kill weed seeds and disease-pathogens in the compost. The “hot” process of composting is an aerobic process. Oxygen is present for the microorganisms to be able to carry out activity that leads to the increase in temperature (hence the term “hot” composting) and eventually the decomposition of the organic matter. The result of a good “hot” composting process is a compost that is free from disease pathogens and weed seeds. However, a large volume of the organic material is lost in the process.

The concept of proper composting especially to kill disease pathogens in diseased crop residues or animal and human manure is not yet fully understood in Vietnam. In most cases, vegetable farmers leave disease-contaminated crop residues in the fields or in canals. Farmers also practice the use fresh manure as organic fertilizer. Both practices bring problems for crops as well as humans. If the crop residues carry disease pathogens, the disease continues to spread. On the other hand, fresh manure carries pathogens and eggs of parasites that may affect humans. For instance, the disease-causing organism of tetanus, a bacterial disease, is transmitted through animal manure. The tetanus bacteria may enter human bodies through open wounds.

Trainers and farmers need to understand the role of the elements carbon and nitrogen in the composting process, i.e., the proper combination of plant and animal materials that can give a good ratio of the elements to obtain a good composting process and output. In this activity we will prepare compost for use in future field studies so that participants understand the principles of preparing and using compost properly as a disease management and soil improvement (not fertilizer) strategy.

### **Objective:**

Go through steps in preparing compost

### **Time required:**

120 minutes

### **Materials:**

Whatever plant material is locally available for compost like water hyacinth or residues of crops in the bean family, crucifers, etc.

Animal manure

Urea

Lime

Ash from rice straw

Water

Materials to cover the pile with like banana leaves or mud (2 – 5 cm thick)

Bamboo poles for aeration and posts

Plastic twine

**Method 1: Using plant material only**

1. Gather the plant material in a corner near the field close to a source of water.
2. Cut up branches of the woody plants and lay these out as the bottom layer of the heap.
3. Place about 20 cm. of soaked water hyacinth and sprinkle evenly a small amount of Urea. Put 20 cm. layers of plant material sprinkling a small amount of Urea each time until a thickness of about one meter is reached. (For every cubic meter of compost, use one kg of Urea. Urea is used in this process to achieve a good ratio between carbon and nitrogen in the absence of animal manure.)
4. After the layers are completed, thrust a pole down to the bottom of the pile in 4 to 6 locations in order to create air channels to the center of the pile.
5. Cover the pile with banana leaves or coconut fronds or 2 – 5 cm layer of mud to prevent the escape of heat and moisture. Remove the cover after one week. Sprinkle water especially on the dried up portions and cover again. Repeat this process every 5 – 7 days to make sure that the pile of compost is always moist (The moisture must be such that one can take a handful of the material and it may be squeezed without crumbling but no water should come out.) to hasten curing.
6. Assign groups on a weekly basis to measure temperature daily. When the temperature goes up to at least 65°C and then goes down to about 25°C - 30°C, turn the pile bringing the outside materials to the center, and the center materials to the outside. Turning should be done at least once when the temperature has gone down but it would be better to do it twice. If the temperature no longer goes up significantly, there is no more need to turn the compost.
7. In about one month, the compost is ready for field application. One indication of well-prepared compost is when its temperature has cooled down to about 25°C - 30°C.

**Method 2: Using plant and animal manure**

Adapted from *Living Soils: Training Exercises for Integrated Soils Management* compiled and edited by Dr. William Settle

1. Layout an area about 1.5 X 1.5m, some distance from the house.
2. Cut between 30 –40 straight wooden or bamboo branches from surrounding trees; each should be about 1.5m tall. The four corner posts should be the biggest and somewhat taller.
3. Insert and/or pound into the ground with a hammer in order to make a wooden cage. Spaces between branches should be 2 – 3 cm. Tie a horizontal branch from each of the four corner posts, to stabilize the structure. Tie the plastic twine along the horizontal branch, from branch-to-branch to further stabilize the structure.
4. Cut succulent weeds from roadside areas, and/or find banana leaves or just about any other leafy materials. Chop these up with a large knife to accelerate the breakdown process.
5. Collect cow dung (chicken and pig dung can also be used – these are higher in N, but also have more odor).
6. Begin with a layer of vegetation about 20 cm in the bottom of the bin; and then a layer of manure, then a second layer of vegetation; then a sprinkling of lime; vegetation; manure; vegetation; lime; etc., until you have reached the top (about 1m).
7. After every layer of vegetation, tamp down the vegetation in order to compress the pile (not too much).
8. After every few layers, sprinkle a few liters of water on the pile to make the material damp, but not soaking wet.
9. After the layers are completed, thrust a pole down to the bottom of the pile in 4 to 6 locations in order to create air channels to the center of the pile.

10. Cover the top with a layer of banana leaves, coconut fronds or 2 – 5 cm layer of mud to keep rain from soaking the pile.
11. Monitor the pile weekly and add water as needed. If the center of the pile becomes dried out, white and “chalky” means you need more water. (The moisture must be such that one can take a handful of the material and it may be squeezed without crumbling but no water should come out.)
12. Assign groups on a weekly basis to measure temperature daily. When the temperature goes up to at least 65°C and then goes down to about 25°C - 30°C, turn the pile bringing the outside materials to the center, and the center materials to the outside.
13. Turning should be done at least once when the temperature has gone down but it would be better to do it twice. If the temperature no longer goes up significantly, there is no more need to turn the compost.
14. If dung is not available, you will need to layer the pile with urea instead. (See Method 1.)

The pile will be completed when the compost is of a dark brown, crumbly consistency, with the odor of fresh earth and when the temperature has cooled down to 25°C - 30°C. This may take three months, depending on the climate.

**Discussions:**

1. Plot temperature on a weekly basis. Explain why the temperature changes. What happens to the materials in the compost heap when the temperature goes up?
2. Why does the volume of the compost decrease? Is this good or not? Why or why not?
3. What is the function of water in composting? What is the function of oxygen? Why do we have to mix compost?
4. How can composting be used as a disease management and soil improvement strategy?
5. What are farmers’ reasons for using or not using compost? Explain.
6. What are farmers’ practices on preparing and using compost? Explain.
7. What other materials in your locality are used to make compost?
8. What can be done to facilitate preparation of compost?



## **NUTRIENT UPTAKE**

### ***Introduction***

Plant nutrients are essential for plant growth. As the plant grows it uses up the nutrients in the soil. In the past this loss in nutrients was replaced by new nutrients delivered from the soil. However, in many cases intensive farming has depleted nutrients in the soil and these have had to be replaced. This can be done by inorganic fertilizers sold on the market or by organic fertilizer such as crop residues, manure, compost, etc. Whereas inorganic fertilizers are very specific and only provide one or two major nutrients, organic fertilizers cover a broad range of different nutrients. Inorganic fertilizers are mainly used when one certain nutrient needs to be applied at a high dosage, such as for nitrogen. In contrast, organic fertilizers have a more balanced nutrient content and besides providing essential macro- and micronutrients they also affect soil physical, chemical and microbial properties. Therefore, the best way to keep the soil fertile, achieve high yields and reduce fertilizer costs is a combination of adding organic matter and commercial inorganic fertilizer. Plants take up both organic and inorganic fertilizer in much the same way through a system of hose-like vessels between the roots and the top of the plant.

### ***Objectives:***

- Describe how nutrients from the soil move through the plant
- Explain the role of water in nutrient uptake from the soil

### ***Materials:***

Water, red ink or dye, two cups per group, plants and two straws

### ***Method:***

1. Go outside by group and find many kinds of plants including rice seedling, morning glory, celery, grasses and other plants.
2. Add water to the two cups and place several drops of the red food coloring. The water should be dark red.
3. Place the plants in the cups with the stems in the cups. Also place the straws in the cups. One straw should be flattened first. Place the plants in a bright place.
4. Wait 90 minutes and observe the plants. What happened to the color of the leaves? How has the red coloring moved in the plants? What does this imply about nutrient uptake from the soil?
5. How do plants take nutrients from the soil?