

**Field Guide Exercises  
for  
IPM in CABBAGE  
(Part II)**

**Vietnam IPM National Programme**

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

## **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 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
- 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 learnings with farmers as well as colleagues in the field of IPM.

# **Field Studies**



## Study 1: Effect of the different management methods on cabbage ecosystem

(This study area will also be used for studies on Slug Control, Effect of Root Maggot and Disease Control)

### Introduction:

For some time, vegetables have been grown with high use of pesticides. Now, consumers are becoming more aware of the effects of pesticides on their health, and on the environment. Reduction of pesticides in vegetable growing is getting a lot of attention. In this study yield, disease and pest and natural enemy populations on vegetables under IPM (based on ecosystem analysis), without pesticides, and under conventional practice will be monitored.

### Objectives:

- Compare the disease incidence, natural enemy and pest populations for different management systems:
  - + IPM - based on weekly ecosystem analysis
  - + No pesticides
  - + Conventional practice, based on the management practices that farmers use in the area
- Compare the economic benefits of the different management methods

### Material:

Area for study: 300 m<sup>2</sup>

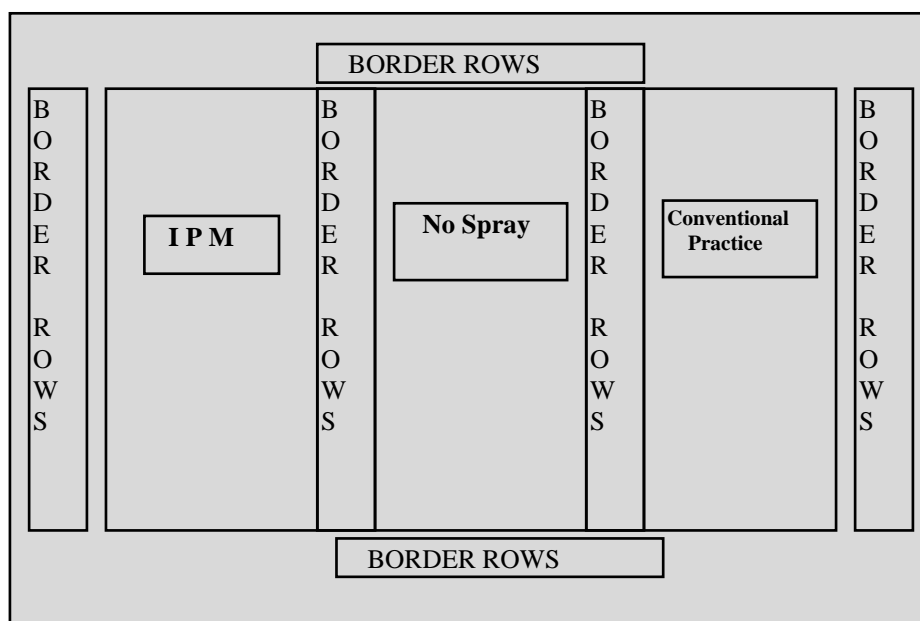
Variety: Common variety with medium growth duration

Materials for study: Hoe, shovel

Fertilizer: Based on fertilizer use in the location for the season

### Method:

- \* The study is set up with 3 treatments, i.e., conventional practice, i.e., management as in farmer's practice, IPM based on ecosystem analysis and unsprayed field. The 3 treatments will be arranged in three plots measuring 100 m<sup>2</sup> each as in the layout below.



- \* Choose the place that represents the region and where soil is uniform in fertility.
- \* The soil preparation, plant density, and water management should be suited to the selected variety, place, season and treatment.
- \* Three treatments will be set up:



## **Study 2: Evaluation of cabbage varieties**

(This study area will also be used for the study on Effect of Root Maggot on Cabbage)

### ***Introduction:***

Many varieties exist with different characteristics in production. Furthermore, varietal selection has a direct bearing on diseases which are primarily controlled by varietal resistance and nitrogen fertilizer levels. In the field, farmers often face many difficulties such as diseases, pest insects, cultivation conditions and costs of production. Therefore, for farmers, it is important to know which variety has high yield, good quality and is popular in the market. This can be different in each location. This study shows how to evaluate different varieties and to select suitable varieties for each region.

### ***Objective:***

Test the performance of different cabbage varieties under local conditions, using two management methods: IPM and unsprayed fields

### ***Materials:***

Area for study: 600 m<sup>2</sup>

Number of varieties: 4

Material for study: Hand sprayer, hoe, shovel.

Fertilizer: Manure, Urea, Potassium, Phosphate

### ***Methods:***

- \* The study is set up with 4 treatments, i.e., 4 cabbage varieties, without replication. Each plot size is 150m<sup>2</sup>.
- \* Field Management: half of the field will be under IPM, and half of the field will be kept unsprayed.

### ***Sampling:***

Weekly sample 10 fixed plants for:

- ◇ Plant development: height of plant, number of leaves, foliage diameter, head diameter, percentage of plant forms head
  - ◇ Disease intensity, pests and natural enemies: composition, density, degree of damage
- Collect all data for economic analysis during the season and at the end of the season measure yields of the different treatments.

### ***Results:***

1. Plot plant development of the varieties tested
2. Plot herbivore populations for each variety under IPM and unsprayed conditions
3. Plot natural enemy populations for each variety under IPM and unsprayed conditions
4. Plot yield of the different varieties under IPM and unsprayed conditions
5. Make economic analysis of the different varieties under IPM and unsprayed conditions
6. Summarize all management practices for each treatment (fertilizer, pesticides, etc.)

### ***Discussions:***

1. Was the quality of the cabbage for each variety the same? Was there a difference in market prices? What was the influence of the management method on the quality of cabbage?
2. Which variety had the highest yield? Which the lowest?
3. Were there differences in herbivore populations between the varieties in different development stages of the cabbage? How did management methods influence herbivore populations?
4. Compare composition and population density of natural enemies in each variety. How did management practices influence natural enemy populations?
5. Compare disease incidence between the varieties. What was the influence of the two management practices (IPM and no spray) on diseases?
6. Was variety the most important factor in cabbage production?
7. Which variety you think would be the most suitable for this region? If you were a farmer, which variety would you choose?



### Study 3: Yield, pest and natural enemy, and disease response to fertilizer

(This study area will also be used for studies on Effect of Root Maggot and Disease Control on Cabbage)

#### Introduction:

Fertilizer is a very important element affecting the cabbage crop. Adding organic fertilizer to the soil improves the soil structure which is important in vegetable growing. Often chemical fertilizer is added to obtain higher yields. In this study we will evaluate the yield, pest and natural enemy response to different fertilizer applications, in order to find out suitable kinds of fertilizer and application methods for this locality.

#### Objectives:

- Try out different levels and kinds of fertilizer and application methods for cabbage to obtain high yield and good quality
- Explain the effect of different fertilizer levels and kinds on composition and density of natural enemy and pest populations, and disease incidence in the cabbage field

#### Materials:

Area for study: 720 m<sup>2</sup>

Variety: Select the cabbage variety most commonly used in the locality. Plant density depends on variety and region.

Materials for study: Hand sprayer, hoe, shovel

Fertilizer: Manure, Urea, Potassium, Phosphate, Ash

#### Method:

\* The study is set up with 6 treatments. The 6 treatments will be replicated 3 times in plot size of 40 m<sup>2</sup> each. Assign treatments to plots randomly.

\* The treatments will use the *same level of composted manure* but different levels of nitrogen.

(Note: For each region the fertilizer *kinds and levels* have to be established after consultation with farmers to find out what are being used locally.)

\* Treatments:

Treatment 1: *Organic fertilizer only*

Treatment 2: *Inorganic fertilizer only*

Treatment 3: *Composted manure & chemical fertilizer (low level)*

Treatment 4: *Composted manure & chemical fertilizer (medium level)*

Treatment 5: *Composted manure & chemical fertilizer (high level)*

\* Field Management: will be based on ecosystem analysis.

\* Method of application:

Timing (DAT)	Type of fertilizer	Dosage	Method
1. Basal	- Manure	50 %	Ditch dressing
	- Ash	50 %	Ditch dressing
	- Phosphate	100 %	Mix with manure
2. Split dressing:			
+ The 1st (10 DAT)	- Urea	5 %	Around plant
+ The 2nd (20-25 DAT)	- Urea	40 %	Around plant
	- Manure	50 %	Ditch dressing
	- Ash	50 %	Ditch dressing
+ The 3rd (30-35 DAT)	- Urea	45 %	Around plant
	- Potassium	100 %	Around plant
+ The 4th (48-52 DAT)	- Urea	10 %	Around plant

**Note: The method of application will be based on what the normal farmers' practices are in the area of the study.**

#### Sampling:

Weekly, sample 10 fixed plants for each replication of the treatments for:

- ◇ Plant development: height of plant, number of (green) leaves, width of foliage, head diameter, percentage of head formation, head tightness, growth duration
- ◇ Composition and density of natural enemy, pest populations, disease incidence

Collect all data for economic analysis during the season and at the end of the season measure yields of the different treatments.

***Results:***

1. Plot plant development for each treatment
2. Plot herbivore populations for each treatment
3. Plot natural enemy populations for each treatment
4. Plot disease incidence for each treatment
5. Plot yield for each treatment
6. Make economic analysis for each treatment
7. Summarize all management practices for each treatment

***Discussions:***

1. What was the effect of different fertilizer levels on plant development and yields? What was the effect of organic fertilizer? Compare the quality of cabbage in the different treatments.
2. How did populations of natural enemies and pest change in the different treatments? Was the composition and density of natural enemy and pest populations different when the dosage of organic fertilizer was increased?
3. Compare disease incidence in the different treatments. If there were differences, why do you think they occurred?
4. Compare economic analysis between treatments. Which treatment was the most economic? Which level do you think a farmer would like to use? Why?

## Study 4: Mono cropping and mixed cropping

### **Introduction:**

Farmers often grow more than one kind of vegetable in the same plot to better use the land and to obtain higher income. While vegetables are mainly short-duration crops, the growth duration of each vegetable crop can be very different. This study will research effect of mono cropping and mixed cropping on cabbage development and ecosystem to identify suitable mixed cropping system for the location.

### **Objectives:**

- Compare the ecosystem of cabbage grown as monoculture with cabbage grown mixed with other vegetables
- Compare the economics of mixed and monocropping
- Identify suitable mixed cropping systems for the location

### **Materials:**

Area for study: 600 m<sup>2</sup>

Variety: Most popular cabbage variety in the location. Plant density depends on what is common in the study area

Materials for study: Hand sprayer, hoe, shovel

Fertilizer: Based on fertilizer use in the location

### **Method:**

- \* The study is set up with 4 treatments, i.e., 3 mixed crops and one mono crop, without replication. Each plot size is 150 m<sup>2</sup>. Assign treatments randomly to the plots.
- \* The suggested treatments are:
  - Treatment 1: Cabbage + Salad
  - Treatment 2: Cabbage + Onion
  - Treatment 3: Cabbage + White field cabbage
  - Treatment 4: Cabbage

**Note: Crops for mixing may vary depending on what is commonly used in the area.**

- \* Field Management will be based on ecosystem analysis.

### **Sampling:**

Weekly, sample 10 fixed plants in each plot for:

- ◇ Plant development: height of plant, number of leaves, colour of leaves, foliage diameter, head diameter...
- ◇ Natural enemy, pest populations, weeds, disease incidence

Also weekly observe and estimate plant uniformity, development and general field situation

Measure yield when a crop gets harvested and collect all data for economic analysis during the season

### **Results:**

1. Plot plant development for each treatment
2. Plot herbivore populations for each treatment
3. Plot natural enemy populations for each treatment
4. Plot yield for each treatment
5. Make economic analysis for each treatment
6. Summarize all management practices for each treatment

### **Discussions:**

1. Compare ecosystems of mono crops and mixed crops. (Consider natural enemy, pest populations, disease incidence, weeds.)
2. What treatment gives the highest profit for the farmer? Is mixing crops worth while or not? If yes, what crop should be mixed to obtain highest profit?
3. What cultivation methods should be practiced to guarantee that both cabbage and the other crop develop well?
4. Are farmers in this area normally using mono or mixed cropping systems? Why? Why not?

## Study 5: Compensation of plant for damage

### **Introduction:**

Consumers often do not like to buy vegetables that have some insect damage or diseases spots. This becomes a reason for farmers to use much pesticides on vegetables from the beginning of the season. Using pesticides increases production cost. It also destroys the environment as well as leaves toxic residues on products. With the government campaign for clean environment, consumers have become more conscious about the vegetables they eat. Consumers are now willing to pay a higher price for vegetables with some damage because then it is clear that pesticide use was low, and so residues are low.

To strengthen farmers' position about not using pesticides it is important to increase their confidence about the ability of a healthy crop to compensate for some damage that occurs. It is important for them to see what kind of damage can be compensated for and what kind of damage will result in quality loss of the vegetables. This study will show the ability of cabbage plants to compensate for damage to sprouts and leaves.

### **Objective:**

Test the ability of cabbage to compensate for damage of sprouts and leaves

### **Material:**

Area for study: 150 m<sup>2</sup> for removal of sprout and 240 m<sup>2</sup> for defoliation

Variety: Most common cabbage variety in the study area

Materials for study: Hand sprayer, hoe, shovel, knife

Fertilizer: Based on fertilizer use in the location

### **Methods:**

#### *a/ Removal of sprouts*

- \* The study is set up with 5 treatments. The five treatments will be replicated three times. The plot size for each replication is measuring 10 m<sup>2</sup> each. Assign treatments randomly to plots.
- \* Time of removal of sprouts:
  - Treatment 1: 7 DAT
  - Treatment 2: 14 DAT
  - Treatment 3: 21 DAT
  - Treatment 4: 28 DAT
  - Treatment 5: 35 DAT
- \* Field Management will be based on ecosystem observations.
- \* Way to remove sprouts: Cut the growing point.
- \* Mark 20 plants in each plot; remove the sprouts of 10 plants and do not remove the sprouts of the remaining 10 (control).

#### *b/ Defoliation*

- \* The study is set up with 8 treatments. The 8 treatments will be replicated three times. The plot size for each replication is 10 m<sup>2</sup>. Assign treatments randomly to plots.
- \* Time of defoliation:
  - Treatment 1: 14 DAT, 25% defoliation
  - Treatment 2: 14 DAT, 50% defoliation
  - Treatment 3: 21 DAT, 25% defoliation
  - Treatment 4: 21 DAT, 50% defoliation
  - Treatment 5: 35 DAT, 25% defoliation
  - Treatment 6: 35 DAT, 50% defoliation
  - Treatment 7: 56 DAT, 25% defoliation
  - Treatment 8: 56 DAT, 50% defoliation
- \* Field Management will be based on ecosystem observations.
- \* Way to defoliate: Cut across slab of leaf except main vein: cut 25% and 50% at 5 different stages of development.
- \* Mark 20 plants in each plot; defoliate 10 plants and do not defoliate the remaining 10 (control).
- \* Observe 20 plants per plot, of which 10 plants had been defoliated and 10 were not defoliated.

**Sampling:**

Sample 20 fixed plants/ plot weekly for:

- ◇ Plant development: height of plant, number of leaves, foliage diameter, head diameter
- ◇ Natural enemy, pest populations, disease incidence

Measure yield at harvest and collect all data for economic analysis during the season

**Results:**

1. Plot plant development for each treatment
2. Plot herbivore populations for each treatment
3. Plot natural enemy populations for each treatment
4. Plot yield for each treatment
5. Make economic analysis for each treatment
6. Summarize all management practices for each treatment

**Discussions:**

1. Compare plant development in the different treatments: sprout removal and defoliation.
2. Can the cabbage plant form a head if the sprout is removed? Up to what plant development stage?
3. In the leaf development and "traï la bang" stages, what should you do if the sprout of the cabbage plant is damaged?
4. Can cabbage compensate for defoliation in the different development stages? What is the effect on yield if cabbage leaves have been eaten in different development stages?
5. What is the effect of cultivation methods on the compensation of plant for damage?

## Study 6: Disease control on cabbage

### **Introduction:**

Generally, diseases are of minor concern in cabbage growing. However, in exceptional cases, diseases like leaf spot can be a problem. The best way to manage disease is the use of resistant varieties but they are not always available. Fertilizer management also influences disease development in the crop. Another important factor is the weather. Sometimes, farmers resort to the use of fungicides in cabbages. In this study we will learn more about the development of diseases under different management practices.

### **Objectives:**

- Observe the development of diseases under different management practices
- Explain disease development
- Implement better methods to reduce diseases

### **Materials:**

Area for study: 450 m<sup>2</sup>

Variety: Most common variety in the study area

Materials for study: Plants, fungicide, marking sticks, boards, string, baskets, shovel, hoe, ruler of 1m, tape measure of 50m, scale of 10kg

Fertilizer: Based on local practices

### **Method:**

- \* The study is set up with 5 treatments. The 5 treatments will be replicated three times. The plot size for each replication is 30 m<sup>2</sup>. Assign treatments randomly to plots.
- \* Treatments:
  - Treatment 1: Fungicide use as in Farmer practice
  - Treatment 2: Fungicide use based on ecosystem analysis
  - Treatment 3: Fungicide use when 1% of leaves have lesions
  - Treatment 4: Fungicide use when 10% of leaves have lesions
  - Treatment 5: No fungicides
- \* Field Management will be based on IPM, i.e., ecosystem observations.

### **Sampling:**

Weekly sample 10 fixed plants per plot for:

- ◇ Plant development: height of plant, number of leaves, diameter of foliage, folding rate, head diameter
- ◇ Natural enemy, pest populations, and weeds

Every three days sample 10 plants at random for:

- ◇ Disease incidence: % of leaves with lesions, disease intensity. Observe if weather conditions favour development of diseases.

Measure yield at different harvesting times and collect all data for economic analysis during the season

### **Results:**

1. Plot plant development for each treatment
2. Plot herbivore populations for each treatment
3. Plot natural enemy populations for each treatment
4. Plot disease incidence for each treatment
5. Plot yield for each treatment
6. Make economic analysis for each treatment
7. Summarize all management practices for each treatment

### **Discussions :**

1. Compare growth and development of plants in the different treatments.
2. How did disease develop in the different treatments? Which plot had the highest disease incidence? Which had the lowest?
3. What factors influence the development of disease? How do they influence disease development?
4. Did regular fungicide applications have influence on pest and natural enemy populations? How did they influence them?

5. Did the use of the two "action levels" (1% and 10% leaves with lesions) allow for a reduction of disease and fungicide applications? What other factors should be considered as well? What are the disadvantages of "action levels"? How can they further be improved?
6. How can studies be set up with farmers to understand more about disease development and spread?
7. What difficulties did you encounter in this experiment?
8. What experiment should be conducted in the future to improve knowledge on diseases and get a better understanding of disease management?

## **Study 7: Development of disease in cabbage**

### ***Introduction:***

In general diseases are not a very big problem in cabbage growing. However, in exceptional cases, some diseases occur in cabbage that can affect yield and quality of cabbage. Cultivation practices, like fertilizer management, and weather conditions influence the development of diseases. In this study we will observe the development of diseases in fields with different fertilizer levels (Fertilizer study) and different management practices (FP/IPM/No spray).

### ***Objectives:***

- Explain the effect of different cultivation practices on the development and spread of disease
- Explain the effect of weather conditions on the development and spread of disease

### ***Material:***

Area for study: Fields that will be used for this study are the plots in the Fertilizer study and in FP/IPM/No spray.

Variety: See Study 1: Effect of the different management methods on cabbage ecosystem

See Study 3: Yield, pest and natural enemy, and disease response to fertilizer

Materials for study: See Study 1 and Study 3

Fertilizer: See Study 1 and Study 3

### ***Method:***

Using marking sticks, mark 5 plants in each plot when diseases start to occur in the different treatments.

Weekly observe these plants.

### ***Sampling:***

Weekly:

- ◇ Sample plant development: height of plant, number of leaves, foliage diameter, head diameter
- ◇ Observe the development of disease: number of lesions, size of lesions, number of leaves with lesions
- ◇ Record the weather conditions (sunny/rainy, temperature)

Make drawings of the disease development in the field

### ***Results:***

1. Assess the different diseases that occurred in the different treatments
2. Plot the development of each disease in the different treatments
3. Record the management practices in the different treatments
4. Record weather conditions during the season
5. Measure yield at harvest and collect all data for economic analysis during the season

### ***Discussions:***

1. What diseases occurred on cabbage? How did they develop?
2. What was the influence of weather conditions on the development of the different diseases?
3. What was the influence of fertilizer on the development of diseases?
4. What was the influence of other management methods on the development of diseases?
5. What are farmers doing to manage diseases? Why?

## Study 8: Different planting densities of cabbage

### **Introduction:**

Depending on each region, the farmers may grow cabbage using high or low plant densities. Plant densities also depend on variety chosen and cultivation practices in the area. Selecting a suitable plant density may help to reduce costs for seeds/seedlings, will create the conditions for cabbage to grow and develop well, and will contribute to high yields and economic benefits.

### **Objectives:**

- Determine the suitable planting density in the study area using local cultivation practices
- Study the effect of density on the yield
- Study the development of diseases, pests and natural enemies at different planting densities

### **Material:**

Area for study: 450 m<sup>2</sup>

Variety: Choose one variety that is common in the study area

Materials for study: Hoe, shovel

Fertilizer: Based on fertilizer use in the location

### **Method:**

- \* The study is set up with 3 treatments, i.e., three different planting densities. The 3 treatments will be replicated three times. The plot size for each replication is 50 m<sup>2</sup>. Assign treatments randomly to plots.
- \* Treatments:
  - Treatment 1: low plant density
  - Treatment 2: normal plant density for that area and variety
  - Treatment 3: high plant density
- \* Field management will be based on ecosystem analysis.

### **Sampling :**

Weekly observe 10 fixed plants/plot for:

- ◇ Height of plant, number of green leaves, diameter of foliage, fold rate, head diameter, head weight
- ◇ Composition and density of pest and natural enemy
- ◇ Disease incidence

Measure yield at harvest and collect all data for economic analysis during the season

### **Results:**

1. Plot plant development for each of the treatments
2. Plot the density and composition of natural enemy and pest populations for the 3 treatments
3. Plot disease incidence for each of the treatments
4. Plot yield for each treatment
5. Make economic analysis for each treatment
6. Summarize all management practices for each treatment

### **Discussions:**

1. Compare growth and development of cabbage plants in the different treatments.
2. How do the farmers decide to select a suitable plant density in their fields?
3. Were the populations of natural enemies and insects different in the different treatments? What about disease incidence?
4. What treatment had the highest yield? What is the influence of plant density on the yield?
5. What would happen in cabbage growing if the costs for varieties and fertilizer would be increased?
6. What is the usual planting density in your local area? Is it necessary to conduct more experiments in your locality to get more information about planting densities?

## Study 9: Effect of foliar fertilizer on cabbage

### **Introduction:**

Nowadays, many kinds of foliar fertilizer are being used in vegetable production. However, there is still little information about the effect of foliar fertilizer on cabbage for farmers to be able to say whether they are indeed useful or not. In this study the effect of foliar fertilizer on cabbage will be assessed.

### **Objectives:** Assess:

- effects of foliar fertilizer on cabbage growth, yield and quality
- effects of foliar fertilizer on disease incidence, on composition and density of natural enemies and pests
- economic efficiency of foliar fertilizer

### **Material:**

Area for study: 90 m<sup>2</sup>

Variety: Use a common local variety planted to the density practiced by farmers in the area

Materials for study: Hoe, shovel, Bayfolan, Complezal (other foliar fertilizers depending on local situation)

Fertilizer: Depends on the local practices (250N-90 P205-70 K20-8300 kg organic + 3400 kg Ash)

### **Method:**

- \* The study is set up with 3 treatments, i.e., two with foliar fertilizers and one control. The 3 treatments will be replicated three times. The plot size per replication is 10 m<sup>2</sup>. Assign treatments randomly to plots.
- \* Treatments:
  - T1: Spray Bayfolan at 5 stages: 7, 14, 21, 28, 35 DAT
  - T2: Spray Complezal at 5 stages: 7, 14, 21, 28, 35 DAT
  - T3: Control, do not spray foliar fertilizer
- \* Field management will be based on ecosystem analysis.

NOTE: Other foliar fertilizers can be used depending on local situation.

### **Sampling:**

Weekly sample 5 fixed plants in each of the replicates of the different treatments for:

- ◇ Height of plant, number of green leaves, diameter of foliage, fold rate, head diameter, head weight
- ◇ Composition and density of pest and natural enemy
- ◇ Disease incidence

Measure yield at harvest and collect all data for economic analysis during the season

At the end of the season, have samples of different treatments analyzed for NO<sub>3</sub> content and some metals in the product

### **Results:**

1. Plot plant development for each treatment
2. Plot yield for each treatment
3. Make economic analysis for each treatment
4. Summarize all management practices for each treatment
5. Summarize NO<sub>3</sub> and metal content in the different treatments

### **Discussions:**

1. Compare plant development in treatments with and without foliar fertilizer.
2. What was difference in speed of new leaf emergence and head diameter between treatments?
3. Were there clear differences in composition and density of pest and natural enemy? Why?
4. Compare yield and economic efficiency between treatments. Which had the highest yield? Which treatment had the highest economic efficiency?
5. Is the use of foliar fertilizer worthwhile or not? Why? Which kind should be used?
6. What is the effect of foliar fertilizer on the quality of cabbage?

## Study 10: Nursery seedbed

### **Introduction:**

The growth and development of cabbage is determined to a large extent by the quality of seedlings which are transplanted. For this matter, it is important to select good seedlings. In vegetable production, preparing and taking care of a seedbed is often difficult because of weather (such as rain, sunshine) and pests. However, since most farmers have no other options but to buy seedlings, it will be useful for seedling growers to have a good knowledge on preparing and taking care of the seedbed nursery not only to produce healthy seedlings but to reduce costs of production as well.

### **Objectives:**

- Prepare good seedbeds
- Implement technically sound practices to overcome unfavourable external conditions in the seedbeds to produce strong and healthy seedlings
- Analyze the ecosystem in the nursery

### **Material:**

Area for study: 8 m<sup>2</sup>

Variety: Most popular cabbage variety in the location

Materials for study: Mulch, hoe, shovel

Fertilizer: Based on fertilizer use in the location for three different treatments

### **Method:**

- \* The study will focus on plant density, fertilizer practices and mulching. It will test:
  - plant density: 3 different plant densities (1 m<sup>2</sup>/treatment). Densities will depend upon what farmers are using locally. (3 treatments)
  - fertilizer practices: 3 different fertilizer treatments (1 m<sup>2</sup>/treatment). Treatments will depend upon local farmer practices. (3 treatments)
  - mulching and no mulching (1m<sup>2</sup>/treatment). (2 treatments)
- \* The plot size for each treatment is 1m<sup>2</sup>.
- \* Management of the seedbeds will be based on ecosystem analysis.

### **Sampling:**

Weekly sample 10 plants per plot for:

- ◇ Plant development: height, number of leaves, etc.
- ◇ Seedbed duration
- ◇ Pest and natural enemy populations: composition and densities
- ◇ Disease incidence

Observe weather condition and general field situation

### **Results:**

1. Plot the plant development for each of the treatments
2. Plot composition and density of pest and natural enemy in the nursery
3. Plot disease incidence in each of the treatments
4. Assess and describe the quality of the seedlings from each of the treatments (colour and height of seedbed, number of leaves, roots)

### **Discussions:**

1. Is there any difference between the treatments? What technical methods should be applied in the nursery to obtain good seedlings?
2. Compare disease incidence in the different treatments. What is the best method to control disease?
3. What methods can be used to overcome unfavourable weather conditions in the nursery?
4. How is the farmer preparing and taking care of the seedbed? What about seeding density, mulching, fertilizer management?
5. What is the best way to pull seedlings and transport them from nursery to field?

## Study 11: Effect of liming

**Introduction:**

In some areas it is necessary to supplement lime to the soil especially where soils have a low pH. In some areas plants may demonstrate deficiency symptoms of such elements as calcium. To learn more about this, in this study we will compare crop development, pest and disease intensity and yields in plots with and without lime.

**Material:**

Area for study: 300 m<sup>2</sup>

Variety: Most popular cabbage variety in the location

Materials for study: Lime, hoe, shovel

Fertilizer: Based on fertilizer use in the location for three different treatments

**Method:**

- \* The study is set up with 2 treatments, i.e., one with lime and one without lime. The 2 treatments will be replicated three times. The plot size for each replication is 50 m<sup>2</sup>. Assign treatments randomly to the plots.
- \* Treatments:
  - Treatment 1: With lime
  - Treatment 2: Without lime
- \* Field management will be based on ecosystem analysis.

**Sampling:**

For the two treatments weekly sample 10 fixed plants for:

- ◇ Plant development: height of plant, number of leaves, foliage diameter, head diameter
- ◇ Natural enemy, pest populations, disease incidence

Measure yield at harvest and collect all data for economic analysis during the season

**Results:**

1. Plot plant development for each treatment
2. Plot herbivore populations for each treatment
3. Plot natural enemy populations for each treatment
4. Plot yield for each treatment
5. Make economic analysis for each treatment
6. Summarize all management practices for each treatment

**Discussions:**

1. Compare the two treatments. Comment on colour and uniformity of cabbage in the two treatments? Is there a difference of head tightness between the two treatments?
2. Compare degree of disease between the two treatments. Is there any difference? Why?
3. Was applying lime in this study worth while or not? Why or why not? How much should be applied?
4. Comment on density of pest and natural enemy in the two treatments? Was there a difference? Why?

## Study 12: Slug control

### **Introduction:**

In some cabbage areas, slugs can be found. Though slugs are not the most serious animals causing damage on cabbage, the degree of damage sometimes is not small, especially when cabbage starts head formation. The quality of the cabbage is lowered, i.e., the development can be bad, as well as the shape of the cabbage head.

### **Objectives:**

- Observe the degree of slug damage on cabbage
- Observe suitable time for slug development
- Implement management methods for slugs

### **Material:**

Area for study: 180 m<sup>2</sup>

Variety: Most popular cabbage variety in the location. Plant density depends on what is common in the study area

Materials for study: Slug baits, pesticides, hoe, shovel

Fertilizer: Based on fertilizer use in the location

### **Method:**

- \* The study is set up with 2 treatments, i.e., one control and one with baits. The 2 treatments will be replicated three times. The plot size of each replication will be 30 m<sup>2</sup>. Use randomized design to assign treatments to plots.
- \* The study will be carried out in the FP/No spray/IPM fields.
- \* In the 3 plots, observe weekly the density of slugs. Use an area of 1m<sup>2</sup> per plot. When the density of slugs and the amount of damage requires control measures, place baits in the field at distances of 1.2 m in T2.

### **Sampling:**

Weekly sample for:

- ◇ Plant development: height of plant, number of leaves, foliage diameter, head diameter...
- ◇ Slug density in the different plots

Measure yield at harvest and collect all data for economic analysis during the season

### **Results:**

1. Plot plant development for each treatment
2. Plot slug densities for each treatment
3. Plot dead rate of slugs per bait
4. Plot yield for each treatment
5. Make economic analysis for each treatment
6. Summarize all management practices for each treatment

### **Discussions:**

1. Was there a difference (slug densities, yield, quality of cabbage) between the control and the treatment with baits? At what stage of crop development did the slugs appear?
2. What methods are farmers using to control slugs?
3. What suggestions do you have to further study this topic?

## Study 13: Effect of root maggot on cabbage

### **Introduction:**

Root maggot was observed recently in cabbage. In the areas where they occurred, cabbage plants that did not develop well specially early in the dry season were found to have root maggots. The occurrence of root maggots is not well understood yet. It is not clear whether they only attack plants that are weak already for some other reason or whether they attack healthy plants.

### **Objectives:** Observe:

- damage symptoms and time of occurrence of root maggots
- damage degree of root maggots on different varieties, different fertilizer levels, sprayed and unsprayed fields

### **Material:**

Area for study:

a./Existing study fields on Variety, Fertilizer, Management (FP/IPM/No spray)

b./Neighboring farmers' fields

c./10 m<sup>2</sup> each of other areas which are low-lying (always wet); high-lying (always dry) and fields in-between (neither always wet nor always dry)

Variety: See Study 1: Evaluation of cabbage varieties

See Study 3: Effect of the different management methods on cabbage ecosystem

See Study 6: Yield, pest and natural enemy, and disease response to fertilizer

Materials for study: See Study 1, Study 3 and Study 6

Fertilizer: See Study 1, Study 3 and Study 6

### **Method:**

- \* The root maggots will be observed in already existing study fields: variety, fertilizer, and FP/IPM/No spray study. Observe also neighbouring farmers fields for root maggot when you observe the study fields. Try to observe 3 areas (10 m<sup>2</sup>/each area) in fields that are:
  - low-lying (always wet)
  - high-lying (always dry)
  - medium field (neither always wet nor always dry)

- \* Set up Insect zoo:

Use a big glass, place a napkin and cabbage into glass

Introduce 3 - 4 couples of adult flies then cover by a piece of mosquito net.

Observe laying and damage of larvae on cabbage root (replicate at least 4 times)

\*

### **Sampling:**

When damage starts to appear:

- ◇ Observe the fields for withered plants and count them. If you find them, uproot them at noon and observe if root maggot is present. Count the number of root maggots. Distinguish plants damaged by root maggots from plants damaged by "sung re" and "lo co re" disease.
- ◇ Count the number of plants damaged by root maggot and by other causes in the variety, fertilizer, and FP/IPM/No spray plots.
- ◇ Observe and count adult flies occurring in the field (distinguish from other kinds of flies).

Collect yield data of the different plots at harvest time, and collect all information during the season needed for economic analysis.

### **Results:**

1. Plot damage of root maggot on different varieties, fertilizer and FP/IPM/No spray treatments.
2. Describe damage symptoms caused by root maggot and effect of cultivation practices, soil and climate on root maggots.
3. Make economic analysis for all treatments.

### **Discussions:**

1. How is the shape, colour and size of larvae, pupa and adult fly of root maggot distinguished from other flies in the field?
2. How does root maggot damage the plant? What symptoms are shown by plant damaged by it? Does the root maggot damage other parts (ie young leaves...) apart from the root? Does the root maggot attack strong and healthy plants or plants that are already weak?
3. Which variety was damaged the most serious by root maggot? Why?
4. In which treatment did cabbage plants have the least damage? Why?
5. In what stage of cabbage development did the root maggot occur?
6. Compare occurrence and damage by root maggots in high, medium or low lying plots. Why was this so?
7. Based on the results obtained, what is the best method to manage this insect?
8. What further study can you design to understand more about root maggots?

# **Ecosystem Analysis Questions**

## **I. 5-7 days after transplanting**

When seedlings are pulled from the seedbed their roots get damaged in one way or another. Immediately after transplanting, seedlings may show some withering. This is because they have not recovered from being transplanted and their function of taking up water and nutrients may still be affected. After some days, they start to recover and develop.

1. Do the seedlings have new roots? Has the seedling recovered or is it still withered? Why? Are there any new leaves? Why is the emergence of new leaves important? What cultivation practices can hasten recovery time? How should irrigation be done to ensure sufficient water in the field? If there are some dead plants in the field, why did they die? What can be done about this?
2. How was the weather this week? How did the weather affect this stage? In the rainy season often strong rain occurs after transplanting. How does this influence the cabbage plant? What cultivation methods do you do practice for the soil and the seedling after rain?
3. What is a good seedling? Why do some farmers buy seedlings instead of prepare seedlings themselves? Compare the strong points and weak points of direct seeding and basket seeding? What kind of seedling is suitable for the rainy season?
4. Is it necessary to fertilize the plants? If yes, what type of fertilizer and fertilizing method should be used?
5. What are the pests in the field? Which is the most harmful?
6. Did you see natural enemies in the same field? How many did you see? Do they also occur in rice? Where do they live in the cabbage field? What do they eat?
7. What is your management decision for this week?

## II. 14 days after transplanting

1. Are there any new leaves? Is it normal if there are old, yellow leaves? If there are small leaves on the plant and the plant is stunted, why is this so? Is this caused by excessive water or lack of nutrients? What cultivation practices make cabbage develop well?
2. How was the weather condition last week? How does the weather influence cabbage growth in this stage? (Much rain, dry, high temperature, cold...)
3. If there were some missing plants, is replanting worthwhile or not? Why?
4. Does the plant need water in this stage? If yes, how should watering be done? Does the plant need fertilizer? What kind of fertilizer? How much? How should fertilizer be applied?
5. Did you see any disease symptom in the field? Which diseases?
6. What pests and natural enemies are there in the field? Compare their occurrence and densities in the three fields. Did you see damage in the field? What was causing it? Normally, there are many kinds of flies in the field. How do you distinguish between them?
7. What is the management recommendation for this week? What was the effect of last week's management decision?

### **III. 21 days after transplanting**

1. How does the plant develop? Are there many new leaves? Is the new leaf larger than the old one? Do new leaves form slowly? Why or why not?
2. Which cultivation practice is most important in this stage? Turn and break the earth around the plant, earth up the root of the plant or fertilize? What kind of fertilizer does the plant require? How much? How do you fertilize? Does the plant need water in this stage? How should watering be done?
3. What is the influence of weather on cabbage growth?
4. What kind of herbivores and diseases are occurring in the field? Which is important? How are the densities compared with last week?
5. What is the effect on yield and quality of cabbage if the sprouts of some plant is removed or pest insects eat part of the leaves? Relate this to results of studies on removal of sprout and defoliation.
6. Which natural enemies did you see in the field? Is the density higher compared to last week? Are there many parasitized cocoons? Are there egg parasites? How many herbivore eggs have parasites?
7. What insects did you collect in the pitfall traps? What is their role and significance in the cabbage ecosystem?
8. How many times did neighboring farmers spray pesticides in their field? Which pesticides? What dosage? What is the effect of pesticides on natural enemies? Compare composition and density of natural enemies and pests in the study fields and farmers' fields.
9. What is the management decision for this week? What was the effect of last week's management decision?

#### **IV. 28 days after transplanting**

1. Compare cabbage development this week with that of last week? Comment on leaf shape and arrangement? If the plant has many large and good leaves in this stage what does it mean for the yield? Why?
2. How does weather influence the cabbage field ecosystem?
3. Is there a need to water and fertilize? If yes, what fertilizers need to be applied? What application method should be used? How should watering be done? Which cultivation practice is most important in this stage?
4. Compare plant development and uniformity between treatments and with other farmer fields. What should be done about the cabbage bed? What does the farmer usually do about the cabbage field at this stage? Why?
5. What major herbivores are there in the field? What are the densities compared to last week? What stages are they in? Do the herbivores influence yield and quality of cabbage? What about diseases?
6. What kind of natural enemies occur in the field? Which species are new? What do they eat? Where do they eat? What kinds of parasites are there in the field? What is the density? What stages of herbivores were parasitized?
7. What is the management decision for this week? What was the effect of last week's management decision?

## **V. 35 days after transplanting**

1. How is the leaf arrangement, shape and size? How will this influence head formation later? Do the leaves reach maximum size in this stage? If yes, why? If no, why?
2. What cultivation practice (water, fertilizer...) do you need to use to improve head formation and obtain higher yield? Why?
3. Normally, at the end of season some plants form heads slowly. Heads are small and can not be sold. Farmers call them "su duc". How do you recognize the stage the cabbage plant is in?
4. Did you see many kinds of herbivore and disease in this stage? Which ones are important? What are the densities compared to last week? Are there damaged plants in the field? What kind of damage were seen? If in the stage of head formation a herbivore eats all tender leaves what will happen? Does the head form? (Relate this to results of sprout removal study.)
5. Which natural enemies occur at this stage? What do they eat and where? How do you preserve them?
6. What is the management decision for this week? What was the effect of last week's management decision?

## **VI. 42 days after transplanting**

1. What percentage of the cabbage have formed heads? Did you see any cabbage plant that did not start head formation yet? What is the reason for this? Is it caused by variety, lack of water, lack of fertilizer or herbivores? Compare the leaf arrangement, shape and size with that of last week? Will the cabbage be able to form heads if it does not go through the stage called "traï la bang - maximum leaf size reached"? Did the cabbage make new root layers after transplanting? What is the significance of this new root layer?
2. How is the weather? How does weather influence head formation stage? How is the disease situation?
3. Does the plant need more fertilizer in this stage? What type of fertilizer, how much and how should fertilizer be applied? What is the effect of water on the plant in this stage? What criteria should be used to decide to water or not? Did you see old leaves fall? Is it normal or is it caused by lack of water, fertilizer and/or disease? What cultivation practices should be done to address these?
4. What are the main herbivores and diseases? Compare their densities with that of last week? What is the effect on the plant?
5. What kind of natural enemies did you find in the field? What are their population densities? What is the ability of natural enemies to control herbivores (refer to Insect Zoo results)? How do you preserve natural enemies?
6. What are farmers doing in their cabbage field in this stage? Why? Is this necessary?
7. What is the management decision for this week? What was the effect of last week's management decision?

## **VII. 49 days after transplanting**

1. In what development stage are the plants? What is your basis for saying this? How does the outer stem develop? Is the number of leaves stable? Comment on uniformity of plants in the field? What should you do about it?
2. Does the plant need more nitrogen? Why? How should fertilizer be applied? Does the plant need water? Why? How should watering be done?
3. Which herbivores and diseases occur in the field? What are their densities? What is their effect on the plants?
4. What natural enemies are present? What are their densities? Comment on relation between pest and natural enemies? Are there some insects in the pitfall traps? What do they eat? What is their role in the cabbage ecosystem?
5. What is the management decision for this week? What was the effect of last week's management decision?

## **VIII. 56 days after transplanting**

1. Comment on head size in comparison with last week? Do you see many old leaves die? Is it normal? Why?
2. What is the water situation? Does dry soil affect yield in this stage? Is it necessary to water regularly? Why? Is there enough fertilizer or not at the moment? If there is lack of fertilizer, is it necessary to apply more? If yes, how will this affect the quality of cabbage? What other environmental conditions favor the development of cabbage in this stage?
3. What kinds of pests and natural enemies are present? What are their densities and relationship? What methods can protect the natural enemies and also limit pest insects from increasing?
4. What do farmers often do in this stage? Is it necessary? What is an important cultivation method to make uniform sizes and hasten formation of heads?
5. What is the management decision for this week? What was the effect of last week's management decision?

## **IX. 63 days after transplanting**

1. What percentage of cabbage plants have started head formation? Did you see any cabbage plant of which leaves did not fold yet? Compare head development and tightness of head this week with last week? Is weather favorable for the cabbage development?
2. Is water or nutrients more important for cabbage in this stage? Why?
3. What herbivores did you observe? What are their densities? Can they cause yield loss in this stage?
4. What kinds of natural enemies are significant in this stage? What are their densities?
5. Are there any disease symptoms in the field? How can you limit their development?
6. What is your management decision for this week? What was the effect of last week's management decision?

## **X. 70 days after transplanting**

1. Comment on head development speed compared to last week? Is the weather good or bad for plant development? Why did well-developed plants have many leaves and start head formation earlier? Why could stunted plants not form heads? From that, what cultivation methods should be applied to obtain a cabbage field with uniform heads?
2. What is the plant requirement for water and fertilizer in this stage? Is it necessary to fertilize and water? If yes, what type of fertilizer and how much?
3. Compare natural enemy densities with that of last week?
4. What kind of herbivores do you have to pay attention to in this stage? What are their population levels? What factors favor pest development which may lead to serious damage?
5. What is your management decision for this week? What was the effect of last week's management decision?

## **XI. 77 days after transplanting**

1. What factors affect quality and yield of cabbage?
2. Is it necessary to fertilize the plant? If yes, what type of fertilizer? What fertilizer does the farmer use? What dosage? Why?
3. Compare herbivore and natural enemy densities in the three fields? Are the herbivores a big concern in this stage? Did you see snails in the field? Where do they damage on the plant? Where do they live and where do they lay eggs?
4. What is your management decision for this week? What was the effect of last week's management decision?

## **XII. 84 days after transplanting**

Some cabbage plants can be harvested.

1. Comment on diameter of heads. Did all the cabbage in the field form heads? In which field are heads most uniform and big?
2. How many heads can be harvested? Are there “cracked heads”? Why? What methods can prevent heads from cracking and spoiling when they have not been harvested?
3. What does the farmer do in this stage? Why?
4. Comment on the price for cabbage now? Is it changing or stable?

# Plant Development

## Seedling Stage ( 1 - 25 DAS)

Seedling stage is the stage between seeding and transplanting. In this stage, the seedling weight is only equal to 1/100 - 1/300 of the total developed plant weight. Seedlings undergo many changes and are exposed to harsh environmental conditions. It is very important to choose appropriate cultivation methods to obtain good seedlings.

### **Objectives:**

- Explain physiological characteristics of seedlings at germination and the development of roots in seedling stage
- Discuss nutrient and water requirements and appropriate cultivation methods necessary for a good nursery to obtain good seedlings

### **Duration:**

120 minutes

### **Materials:**

Soaked seeds, incubated seeds and germinating seeds; seedlings with 1 - 2 leaves (10 days old) , 4 - 5 leaves (15 days old); paper; crayons; magnifying glass...

### **Method:**

Observe, describe, and draw all the stages of the seedling

### **Discussions:**

1. What part emerges first when the cabbage plant germinates? How many days after seeding does the cotyledon emerge?
2. How many roots are there in each stage? What are their functions for growth and development of the plant in each stage?
3. How many leaves are there in each stage? What is the colour and the arrangement of leaves in each stage? When were new leaves formed? Did you see old leaves that were dead? Is this normal?
4. What are the characteristics of a good seedling? What are the characteristics of a good nursery? How do you make a good nursery? Compare 2 seeding methods: direct seeding and seeding in a basket.
5. What is the influence of weather and climate on the cabbage plant in this stage?
6. What kinds of herbivores occur during this stage? What is the best management method for these herbivores?
7. Is it necessary to apply fertilizer before transplanting? What is the water requirement of seedbeds? What watering method should be used?

## **Recovery Stage (1 - 10 DAT)**

After transplanting, the plant can not take up water and nutrients immediately so it will show withering for sometime. After that, the plants recover and the roots develop again normally. This is the recovery stage. The length of this stage depends on weather conditions and cultivation practices.

**Objective:** Explain:

- physiological withering of cabbage after transplanting
- factors that affect this stage
- cultivation practices needed to reduce this state and hasten recovery

**Duration:**

120 minutes

**Materials:**

Cabbage plants of 1, 3-5, 7-10 days after transplanting

Markers, crayon, magnifying glass, large paper...

**Method:**

Observe, describe, draw leaf form, number of leaves, roots, plant height

**Discussions:**

1. Comments on leaf and root development of plants at 1 DAT, 3-5 DAT, and 7-10 DAT. What are the differences of plants in the 3 stages?
2. How long does this stage last? What factors lengthen duration of the recovery stage (soil, water, weather)? How does this affect plant development? How many days after transplanting do the roots start to develop again and the plants become fresh again? What cultivation method can shorten this period?
3. What is the water requirement of the plant in this stage? How does the weather affect the plant after transplanting (sunny, rainy)? What methods can be applied to overcome effect of weather on plants?
4. Is fertilizer important in this stage? Why? What is the importance of nutrients in this stage? Why?
5. What kinds of herbivores occur in this stage? How do they affect the plant?

## **Stem and leaf development stage (11 - 25 DAT)**

At this stage, plants will have recovered and started to absorb nutrients and water normally. Therefore, plant requirements for water and nutrients are more. Plants develop faster at this stage.

### ***Objectives:***

- Explain stem, leaf and root development
- Discuss factors which influence plants at this stage
- Discuss requirements of plants and suitable management methods

### ***Duration:***

120 minutes

### ***Materials:***

Cabbage plants at 10-15 DAT, 15-20 DAT and 20-25 DAT  
Large paper, pen, pencil, crayons and notebook...

### ***Method:***

Observe, describe colour and the arrangement of leaves, the number of leaves and roots in each stage. Draw the plants of different stages.

### ***Discussions:***

1. How many new leaves emerge in each stage? Do new roots form when new leaves emerge? How long are the roots? Are these tap roots or adventitious roots? Describe the colour of roots?
2. How long does this stage last? How do you shorten or lengthen this stage? What factors cause this stage to be longer or shorter?
3. What are the requirements of plant for water and fertilizer? What are suitable methods for watering and applying fertilizer?
4. What herbivores occur at this stage? How do they damage plants? Does this affect yield directly?
5. Can plants start head formation if young sprouts are damaged in this stage? Why? (Relate this to results of the study on removal of sprout.)
6. What cultivation methods should be applied to obtain strong, healthy cabbage plants?

## **Foliage development stage (25 - 45 DAT)**

Before the cabbage plant starts head formation, leaves change to uniform green, spread, and seem perpendicular to the cabbage stem. In this stage the plant assimilates well so the number of leaves and the diameter of foliage increase fast. The leaf size reaches a maximum.

### ***Objectives:***

- Explain plant development, leaf arrangement, and root development
- Discuss conditions related to head formation

### ***Duration:***

120 minutes

### ***Materials:***

Cabbage plants of 25-30 DAT, 35 DAT and 40-45 DAT  
Pens, crayons, ruler, large paper

### ***Method:***

- \* Observe, describe and draw leaf development and leaf shape before head formation.
- \* Count number of leaves, measure leaf size.

### ***Discussions:***

1. How long does this stage last? What factors affect the duration of this stage? Will the cabbage be able to form a head if the plant does not go through this stage? If yes, what happens to the yield. Is it normal?
2. How many leaves are there on the plant? What is the size, shape and colour of leaves? Comment on leaf arrangement. What is significance of leaf arrangement to head formation?
3. How does the weather and climatic conditions affect plant development? What cultivation method (watering, fertilizing...) is necessary to produce tight heads and obtain higher yield?
4. Can the cabbage form a head if the top of the plant is damaged? Why? Why not? If some part of leaves are eaten by insects, what will happen to the plant? (Refer to results of compensation study.)
5. What kinds of herbivores and natural enemies occur in this stage?

## Head formation stage

When the diameter of the foliage reaches its maximum, the plant starts head formation. In this stage, plant requirements for nutrients and water are high.

**Objectives:** Explain:

- plant development in this stage, especially, changes in leaf development (shape, size and colour) and function of leaves
- factors that affect head formation and cultivation methods needed in this stage

**Duration:**

120 minutes

**Materials:**

Plants starting head formation and plants with heads already formed

Large paper, crayons and magnifying glass

**Method:**

- \* Observe, describe and draw parts of plants (number of leaves, leaf form, colour and arrangement, stem circumference and foliage diameter).
- \* Cut the plants to observe and draw leaf arrangement.

**Discussions:**

1. Comment on leaf shape before head formation. Is the head formed by folding of inner or outer leaves? To get a big and tight head what cultivation methods do you need to apply in this stage?
2. What is the influence of weather and climatic conditions on cabbage plant in this stage? What management methods may be applied if the weather is bad during the head formation stage?
3. What are the plant requirements for water and nutrients? What type of fertilizer should be applied? What methods of watering and fertilizer application should be used?
4. What kinds of head is the most popular in market?
5. Comment on head development of plants in the field.

## Harvest stage

### **Objectives:**

- Recognize plant shape in this stage
- Discuss factors related to yield and quality of head and cultivation methods needed

### **Duration:**

120 minutes

### **Materials:**

Plants at harvest stage

Paper, crayons, knife, ruler...

### **Method:**

Observe, describe and draw the cabbage plant at harvest stage (count number of green leaves, colour of outer leaves and leaves that surround the head). You can try to measure the tightness of head using the following formula:

$$P = \frac{H-h}{n}$$

Of which: P: the tightness of head  
H: the height of head  
h: the height of inner stem  
n: number of leaves that formed head (leaves with >2 cm length)

If  $P > 1$ : not tight

$P = 1$ : medium

$P < 1$ : very tight

### **Discussions:**

1. Comment on shape of leaves.
2. What cultivation methods should be used in this stage?
3. Comment on the tightness of heads. Why were there differences in tightness of heads? What management methods may be applied to get more tight heads?
4. How does the farmer measure the tightness of heads in this stage? Is this a good way to measure tightness? Should you do it the way farmers do?
5. What kinds of herbivores occur in this stage? What management methods should be applied for these herbivores?