

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

Vietnam IPM National Programme

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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 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 Bean

The General Guide contains exercises along the following areas:

- Research Methods
- Field Studies
- Economic Threshold Levels
- Ecosystem
- Plant Development
- Insect Zoos
- *Bacillus Thuringiensis*
- Pesticides
- Diseases
- Weather
- Composting

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 different management methods on tomato ecosystem

(This study area will also be used for the study on Disease Control in Tomato)

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

Materials:

Area for study: 300 m²

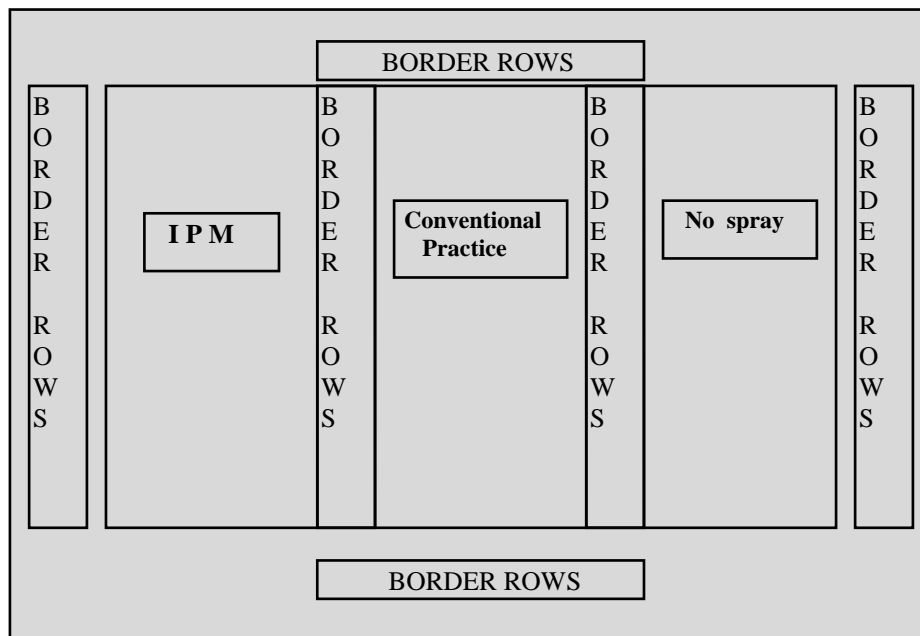
Variety: Tomato variety will be the most common in the study area; plant density to be based on local practices

Materials for study: Tomato plants, stick to make grid shelter, insecticide, *thuoc kich thich*, marking sticks, basket, shovel, hoe, ruler of 1m, tape measure of 50m, scale of 10 kg

Fertilizer: Cattle manure, nitrogen, kali based on local practices

Method:

- * The study is set up with 3 treatments, i.e., IPM based on ecosystem analysis, conventional practice, i.e., management as in farmer's practice, and unsprayed field. The 3 treatments will be arranged in three plots measuring 100 m² 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:

- T1: IPM: based on ecosystem analysis
 T2: No spray
 T3: Conventional practice, i.e., management as in farmer practice
- * For each treatment, there shall be five rows such that each group shall have one bed per treatment for data collection
 - * Border rows of the size of one bed will be planted between treatments and all around the entire study; the border rows shall be outside of the 100 m² per plot.
 - * Fertilizer management: For IPM plot based on ecosystem analysis
 For Conventional Practice and No Spray Plots based on farmers practice
 - * Observe and analyse ecosystem every 7 days
 - * Place pitfall traps (6 traps/ treatment/ observe every week) on the evening before sampling

Sampling:

Sample weekly 10 plants in each plot for:

- ◇ Plant development: height of plant, number of leaves, number of fruits, record the morphological characteristics in different plant stages
- ◇ Natural enemy, pest populations, weeds, disease incidence

Collect and count numbers of insects caught in pitfall traps in each plot which were placed the previous evening.

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 plant growth and development in the different treatments.
2. What management practices are important in growing tomato (cultivation practices, fertilizer management, watering, etc.)?
3. What natural enemies occur? What is their significance? How can they be protected and also limit the damage of pests?
4. What pests occur in the tomato field? Which was the most important in each stage? How do you control them and also protect the natural enemies?
5. Compare disease incidence in each of the treatments. How did the weather and cultivation practices influence disease development? Why?
6. Compare yields in each of the treatments.
7. Which management method was most economic? Why? Was there a difference in quality of tomatoes in the different treatments? What about the price?
8. How many times did you spray pesticide? Was it necessary? What was the effect of pesticide use on natural enemies?
9. What difficulties occurred during the experiment?
10. What further studies do you recommend to better understand and manage the ecosystem of tomato?

Study 2: Evaluation of tomato varieties

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 tomato varieties under local conditions, using two management methods: IPM and unsprayed fields

Materials:

Area for study: 600 m²

Variety: four varieties (May vary depending on what is locally available.)

Materials for study: Sticks to make shelter, bamboo sticks to mark on, hand sprayer, scale of 10 kg, baskets, hoe, shovel, wire, tape measure of 50m, ruler of 1m

Fertilizer: Cattle manure, nitrogen, kali (Quantity and application methods to be based on local situation.)

Method:

- * The study is set up with 4 treatments, i.e., 4 tomato varieties, without replication. Each plot size is 150m².
- * 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 in each plot for:

- ◇ Plant development: height of plant, number of leaves, number of flowers, number of fruits, record the morphological characteristics in different plant stages
 - ◇ Weeds, 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. Compare growth and development of the four varieties during the season. How did the management practices influence growth and development of the four varieties?
2. Compare herbivore populations between the varieties in different development stages of the crop. How did management methods influence herbivore populations?
3. Compare composition and population density of natural enemies between varieties. How did management practices influence natural enemy populations?
4. Compare disease incidence between the varieties. What was the influence of the two management practices (IPM and no spray) on disease incidence?
5. Was the quality of tomatoes for each variety the same? Was there a difference in market prices? What was the influence of the management method on the quality of fruits?

6. Which variety had the highest yield? Which had the lowest? How did management methods influence yields? Which management methods and variety were most economically viable?
7. Which variety would be the most suitable for this region? If you were a farmer, which variety would you choose?
8. Was variety the most important factor in tomato production? What about other management practices (fertilizer, etc.?)
9. What difficult and favourable conditions appeared during the experimental period ?
10. What experiment on varieties would you recommend in the future?

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

(This study area will also be used for the study on Disease Control in Tomato)

Introduction:

Fertilizer is a very important element affecting the tomato 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 tomatoes 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 tomato field

Materials:

Area for study: 600 m²

Variety: The variety used will be the one most commonly used the study area.

Materials for study: Marking sticks, bamboo sticks to make shelter, scale of 10 kg, basket, hoe, shovel, ruler of 1m, tape measure of 50 m, string

Fertilizer: Cattle manure, nitrogen, kali (Quantity and application methods to be based on farmers practices and recommendations from the offices concerned.)

Method:

- * The study is set up with 5 treatments. The 5 treatments will be replicated 3 times in plot size of 40 m² 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.

Sampling:

Weekly sample 10 fixed plants in each plot for:

- ◇ Plant development: height of plant, number of leaves, number of flowers, number of fruits, record the morphological characteristics in different plant stages
 - ◇ Weeds, 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 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 fertilizer treatments? What was the effect of organic fertilizer?
2. How did fertilizer affect the herbivore populations during the season?
3. Compare composition and density of natural enemies in the different treatments.
4. Compare development of disease in the different fertilizer treatments? Why is this so?
5. What fertilizer treatment had the highest yield and economic efficiency? Which one had the lowest? How did fertilizer influence the quality of the tomatoes?
6. What difficult and favourable conditions occurred during the experimental period?

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 the development and ecosystem of tomatoes to identify suitable mixed cropping system for the location.

Objectives:

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

Materials:

Area for study: 450 m²

Variety: Tomato variety will be the most common in the the study area; plant density to be based on local practices

Materials for study: Tomato plants, onion, salad, marking sticks, bamboo sticks to make shelter, scale of 10 kg, basket, hoe, ruler of 1m, tape measure of 50 m, string

Fertilizer: Cattle manure, nitrogen, kali based on local practices

Method:

- * The study is set up with 3 treatments, i.e., 2 mixed crops and one mono crop, without replication. Each plot size is 150 m². Assign treatments randomly to the plots.
- * The suggested treatments are:
 - Treatment 1 : tomato only
 - Treatment 2 : onion and tomato
 - Treatment 3 : salad and tomato

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

- * Field Management will be based on IPM, i.e., ecosystem observations.

Sampling:

Weekly, sample 10 fixed plants in each plot for:

- ◇ Plant development: height of plant, number of leaves, colour of leaves, number of fruits, record the morphological characteristics in different plant stages
- ◇ Sample natural enemy, pest populations, weeds, disease incidence on tomato and other crops.
- ◇ Estimate: uniformity of 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. How did mixed cropping affect the development of the tomato plant?
2. Compare ecosystems of mono crops and mixed crops. (Discuss natural enemy, pest populations, disease incidence, weeds.)
3. What treatment is 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?
4. What cultivation methods should be paid applied to guarantee that both tomato and the other crops develop well?
5. 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 tomato plants to compensate for defoliation.

Objective:

Test the ability of tomato to compensate for defoliation (25% and 50%) at different periods of crop development

Materials:

Area for study: 150 m²

Variety: Variety that is used locally, planted to density commonly used in the study area

Materials for study: Tomato plants, marking sticks, scale of 10 kg, basket, hoe, ruler of 1m, tape measure of 50 m, string, knife

Fertilizer: Cattle manure, nitrogen, kali 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 10 m². Assign treatments randomly to plots.
- * Defoliation method : 10 plants per treatment; mark each plant
- * Treatments:
 - At 15 DAT (development of stem and leaves stage):
 - Treatment 1 : defoliate 25% of the leaf area
 - Treatment 2 : defoliate 50% of the leaf area
 - At 30 DAT (flowering and fruit setting stage)
 - Treatment 3 : defoliate 25% of the leaf area
 - Treatment 4 : defoliate 50% of the leaf area
 - Treatment 5 : No defoliation (control)
- * Field Management will be based on IPM, i.e., ecosystem observations.

Sampling:

Sample weekly 5 fixed plants in each plot for:

- ◇ Plant development: height of plant, number of leaves, number of fruits, record the morphological characteristics in different plant stages
- ◇ Natural enemy, pest populations, weeds, disease incidence

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 plant development in the different treatments.
2. Compare yield in the different treatments.
3. Can tomato compensate for defoliation in the different development stages? What is the effect on yield if tomato leaves have been eaten in different development stages?
4. What is the effect of cultivation methods on the compensation of plant for damage?
5. Compare disease incidence in the different treatments.
6. Compare pest and natural enemy populations.

Study 6: Disease control on tomato

Introduction:

Diseases, especially Phytophthora, often cause problems in tomato growing. The best way to manage disease is the use of resistant varieties but they are not always available. Fertilizer management influences disease development in the crop to a large extent. Another important factor is the weather. Fungicides are frequently used in tomatoes for disease control. However, this may not necessarily be the best method. In this study the development of diseases will be followed under different management practices.

Objectives:

- Observe the development of diseases under different management practices
- Discuss factors which influence disease development
- Implement better methods to reduce diseases

Materials:

Area for study: 540 m²

Variety: Most common variety in the study area

Materials for study: Tomato plants, fungicides, marking sticks, boards, bamboo stick to make shelter, string, baskets, shovel, hoe, ruler of 1m, tape measure of 50 m, scale of 10kg

Fertilizer: Cattle manure, nitrogen, kali based on local practices

Method:

- * The study is set up with 6 treatments. The 6 treatments will be replicated three times. The plot size for each replication is 30 m². 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
 - Treatment 6: Use of lime, based on ecosystem analysis
- * 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, , number of fruits
- ◇ 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. Compare 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. How did regular fungicide applications influence pest and natural enemy populations?
5. Did the use of the two "action levels" of 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 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 tomato

Introduction:

Diseases can sometimes be a problem in tomato growing. This may be influenced to a large extent by cultivation practices and weather conditions. To learn more about these, 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 cultural practices on the development and spread of disease
- Explain the effect of weather conditions on the development and spread of disease

Materials:

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 tomato 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:

Mark with a stick 5 plants in each plot when diseases start to occur in the different treatments. Weekly observe these plants.

Sampling:

Weekly observe the development of disease:

- ◇ Number of lesions
- ◇ Size of lesions
- ◇ Number of leaves with lesions

Make drawings of the disease development in the field

Record the weather conditions weekly (sunny/rainy, temperature)

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. Sample plant development: height of plant, number of leaves, flowers set, fruits formed
6. Measure yield at harvest and collect all data for economic analysis during the season

Discussions:

1. What diseases occurred on tomato? 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: Nursery seedbed

Introduction:

The growth and development of tomatoes 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 also to help farmers 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

Materials:

Area for study: 8 m²

Variety: Most commonly used tomato 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: test 3 different plant densities (1 m²/ treatment). Densities will depend upon what farmers are using locally. (3 treatments)
 - Fertilizer practices: test 3 different fertilizer treatments (1 m²/ treatment). Treatments will depend upon local farmer practices. (3 treatments)
 - Mulching and no mulching (1m²/treatment) (2 treatments)
- * 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 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 seedlings, number of leaves, roots).

Discussions:

1. Did you observe differences between plants in different treatments? What cultivation methods should be applied in the nursery to obtain good seedbed?
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 does the farmer prepare and care for the seedbed? How different are the farmer's practices on seeding density, mulching, fertilizer application from your practices?
5. What is the best way to pull seedlings and transport them from nursery to field?

Study 9: Effect of growth stimulator on fruit setting

Introduction:

In tomato production, farmers often use growth stimulators in the fruiting stage to increase yields. However, there is not enough evidence about increasing yields from using growth stimulators. In this study we will have a look at the effect of the use of these products.

Objectives:

- Analyze growth, development, fruit production with and without using growth stimulators
- Evaluate economic efficiency of use of growth stimulators

Materials:

Area for study: 30 m²

Variety: Tomato variety will be the most common in the the study area; plant density to be based on local practices

Materials for study: Tomato plants , marking sticks, hoe, shovel, baskets, scale of 10kg, ruler of 1m, chemical.

Fertilizer: Cattle manure, nitrogen, kali based on local practices

Method:

- * The study is set up with 2 treatments. The plot size of each treatment is 15 m².
- * Treatments:
 - Treatment 1 : Control, without use of growth stimulator
 - Treatment 2 : Use growth stimulator based on farmers' practices
- * Field management in the study will be based on ecosystem analysis.

Sampling:

Observe weekly 20 fixed plants per treatment for:

- ◇ Plant development: height of plant, number of leaves, number of fruits, record the morphological characteristics in different plant stages
- ◇ Natural enemy, pest populations, weeds, disease incidence
- ◇ Measure yield at different harvesting times and collect all data for economic analysis during the season

Results:

1. Plot plant development for each treatment. Describe the shape, colour of the plants in the two treatments. Compare the percentage of flowers and fruit formation for the two treatments.
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. How does the growth stimulator affect the growth and development of the plant? How does it influence flower and fruit setting? Compare the percentage of fruit formation in the two treatments.
2. Compare yields in the two treatments. Compare economic benefits.
3. What do you think about the quality of fruits in the treatments?
4. When does the farmer use the chemical? What chemicals are farmers using? What are the farmers reasons for using these chemicals? What do you think about the use of growth stimulators?
5. What are the possible effects of the chemical on health of humans and the environment ?
6. What difficulties occurred during the experiment?

Ecosystem Analysis Questions

I. 0 - 7 days after transplanting

1. Discuss *earlier cultivation practices* and relate to plants at this stage:
 - a. What are the criteria for selecting a good variety? Growth duration, form, size, number of leaves, herbivore or disease resistance? Do the criteria change depending upon the season?
 - b. How did you prepare the soil? (Making a bed or row; making a planting hole; make ditches; soil structure?) Why?
 - c. How did you fertilize (what kind, amount, method)? Why?
 - d. How did you plant seedlings? What time of the day did you plant? How did you put the seedlings; make the planting holes; fill up the hole? What is a suitable planting distance?
 - e. How did you water the plants? What difference does dry and wet soil make to plants?
2. *Plant*: Have plants recovered? If no, why not? Are there new leaves? How do new roots develop? How many days is it after transplanting? Are there any changes in plant height? Are there dead or yellow leaves?
3. *Pest insects and natural enemies*: What kind of herbivores and diseases did you see in the tomato field? What are their densities? Where did they come from? What is the role of natural enemies?
4. *Management decisions*: What is the management decision for this week? What do you expect to happen in the field next week?

II. 8 - 14 days after transplanting

1. What was the effect of last week's decision?
2. *Weather*: How is the weather affecting the plant? (sunshine, wet weather, rain, fog...)
3. *Plant*: Do you still observe plants dying? What could be the reason for this? Does the soil have enough or excess of water? Comment on plant growth, number of leaves, colour of leaves. Comment on root development. Are there many or few?
4. *Pest insects, diseases and weeds*: Did herbivore populations and diseases change in comparison with last week? (Are there any new herbivores? Did some increase? Did some reduce?) What kind is the most important? How many are there? Are they causing damage? Are there any weeds? How does it influence growth of plant?
5. *Natural enemies*: Which natural enemies did you see in the field? Are there any new natural enemies? How can you get information on their functions? What are your suggestions for Insect Zoo studies on these insects?
6. *Management decisions*: Do the plants need fertilizer and/or water? What method to fertilize or water will you use? What is the management decision for this week?
7. *Farmers' practices*: What cultivation practices are farmers using? Why? Have you ever discussed with experienced farmers? Did you test their methods?

III. 14 - 21 days after transplanting

1. What was the effect of last week's decision?
2. *Weather*: How is the weather affecting the plant? (sunshine, wet weather, rain, fog...)
3. *Plant*: Are there new branches? Is the plant growth and development normal? Are the plants uniform throughout the whole field? Are there some plants which could not develop? Why? What is the leaf color? Comment on develop of the bottom leaf. Is it normal? Are there any flowers on the plant? What is the significance of the first sets of flower?
4. *Pest insects, diseases and weeds*: What is the change in herbivore population compared to last week? What is its significance in this stage? Which cultivation practices, weather conditions are affecting disease development? Do we need to remove weeds?
5. *Natural enemies*: What natural enemies (predator, parasite) are there in the field? How many are there? What are the results of insect zoo and field observations?
6. *Management decisions*: What is the management decision for this week? Is the soil wet enough? Does the field need water? What are the fertilizer requirements during this stage (nitrogen and potassium)? How do you cover the bed? What are the techniques?
7. *Farmers' practices*: What do farmers do to prevent herbivores and disease from damaging the crop? Did you observe control fields or farmers' fields in the area? What is the difference between your method and that of the farmers? Why? Are there differences between cultivation practices in this area with those of other areas?

IV. 21 - 28 days after transplanting

1. What was the effect of last week's decision?
2. *Weather*: Comment on the weather. How does it influence plant growth and diseases?
3. *Plant*: How do stems and leaves of tomatoes develop? How many leaves does the plant have? How many branches does the plant have? What is the significance of these branches? Is it necessary to prune branches? Why? (Develop a field study to test this!) Comment on plant height. Is the plant firm or soft? Does the plant need a support? Why? Why not?
4. *Pest insects, diseases and weeds*: What kind of herbivores and diseases are present? What are their densities? Which one is important? What environmental conditions favour the increase of diseases?
5. *Natural enemies*: What kind of natural enemies are present? What is the role of these natural enemies?
6. *Management decisions*: What is the management decision for this week? What cultivation practices are needed in this stage? Water? Fertilizers: type of fertilizer and amount? Why? Why not?
7. *Farmers' practices*: Compare your method with farmers' method in the area? Did you ask farmers why they practice those methods?

V. 28 - 35 days after transplanting

1. What was the effect of last week's decision?
2. *Weather*: Comment on the weather condition? How do these conditions influence the development of disease?
3. *Plant*: Comment on plant development: height, leaf length, new buds, number of leaves, internode length. Comment on root development. How does a bunch of fruits form? How many bunches are there on the plant? How many fruits are there on the bunch? Are there any new sets of flowers? How many sets are there on plant?
4. *Pest insects, diseases and weeds*: What kind of pests and diseases are present? What are their densities?
5. *Natural enemies*: What natural enemies did you see in the field? What is the role of these natural enemies in the ecosystem?
6. *Management decisions*: What is the management decision for this week? What kind of nutrient does the plant need in this stage? Is the soil wet enough? Which cultivation practices do you need to use: water, remove buds on the plant, remove top of plant, and/or fertilize? How do you do these? What are those cultivation practices based on?

VI. 35 - 42 days after transplanting

1. What was the effect of last week's decision?
2. *Weather*: How is the weather influencing the growth and development of the plant? How is it influencing development of diseases?
3. *Plant*: Comment on plant growth and development: height, number of leaves, leaf length? How does the number of bunches of flowers and fruits compare with that of last week? What cultivation practice should be applied to obtain a higher percentage of fruit setting? Did you see flowers and fruits fall? Is this normal? Will it affect yield? What conditions cause flowers to fall? What is the significance of old and yellow leaves at the bottom? Why do some farmers remove them?
4. *Pest insects, diseases and weeds*: What herbivores and diseases occur in this stage? Which is important? What are their densities? Comment on damage caused by these herbivores and diseases?
5. *Natural enemies*: What natural enemies do you see in the field? What is the role of these natural enemies?
6. *Management decisions*: What is the management decision for this week? What is the effect of fertilizer on the plant at this stage? What type of and how much fertilizer does the plant need? What method of application should be employed? What is the effect of water on plant in this stage? Does the plant need water? What method of watering should be used?
7. *Farmers' practices*: What are farmers in neighbouring fields doing now?

V. 42 - 50 days after transplanting

1. What was the effect of last week's decision?
2. *Plant*: Comment on plant development in this stage: stem, leaves.... Did you see some plants with long stems, big tops, many leaves? Is this good or bad? Why? Why not? What is the number of bunches of flowers and of fruits in comparison with last week?
3. *Pest insects, diseases and weeds*: Which herbivores and diseases occurred this week? Compare their densities with those of last week?
4. *Natural enemies*: What natural enemies occur in the field? What is their role? Compare their densities with those of last week?
5. *Management decisions*: What is the management decision for this week? Which cultivation practices do we need to do in this stage: fertilize, water, maintain beds...?
7. *Farmers' practices*: What are farmers doing to stimulate fruit setting and increase the number of fruits? When do farmers decide to treat or not? How do you compare your study fields with farmer fields in the same area?

VI. 50 - 57 days after transplanting

1. What was the effect of last week's decision?
2. *Plant:* Comment on plant development in this stage. Compare the number of flower bunches and of fruit bunches with those of last week. Are there any fruits ripe enough to harvest? If you harvested now, what would your reason for harvesting be?
3. *Pest insects, diseases and weeds:* What herbivores are present this week? What factors will result in their increase or reduction next week? Comment on the development of diseases? What factors and how do they influence the development of disease?
4. *Natural enemies:* What natural enemy occur in the field? What is the role of these natural enemies?
5. *Management decisions:* What is the management decision for this week? What cultivation practice should be done: fertilize, water...?
6. *Farmers' practices:* How does your method of management compare with those of neighboring farmers?

VII. 63 days after transplanting

1. What was the effect of last week's decision?
2. *Plant:* Comment on fruit formation in this stage: quantity and fruit size? What conditions are affecting fruit formation?
3. *Pest insects, diseases and weeds:* What kind of pests occur at this stage? Why? How do you manage these pests? What diseases are present this week? Compare the disease situation this week to last week? What conditions favour their development?
4. *Natural enemies:* What natural enemies are found in the field? What is the role of these natural enemies? What are their densities?
5. *Management decisions:* What is the management decision for this week? Is it necessary to apply nitrogen in this stage? What about after each harvest?

VIII. 71 days after transplanting

1. What was the effect of last week's decision?
2. *Plant*: Comment on plant development this week: stem, leaves.... Comment on fruit and leaf shape. Is it different from fruits on which stimulants were used? What fruits ripened first?
3. *Pest insects, diseases and weeds*: What herbivores and diseases are present in the field this week? Compared this to last week.
4. *Natural enemies*: What natural enemies did you observe? What are their densities?
5. *Management decisions*: Do you need to water or fertilize? When will you harvest? What is the price of tomato now? Will the price change in the coming days? How?

Plant Development

Seedling Stage

Objective: Explain:

- Formation and development of root, stem and leaf in seedling stage of tomato
- Physiological characteristics and nutrient requirement in seedling stage
- Cultivation practices necessary in this stage

Duration:

120 min.

Materials:

Tomato: seeds 2 days after soaking and incubation

Plants at 7 DAS, 15 DAS, 20 DAS, 25 DAS

Paper, pen, ruler and scissors

Method:

- * Observe and describe morphological characteristics, draw growth stages of tomato.
- * Measure, count and describe growth criteria: height of plants, length of roots, number of leaves.

Discussions:

1. What is a good seed? What is the criteria for a good seed?
2. What is a good seedling? What is the criteria for a good seedling?
3. Describe morphology of the tomato plant. How many roots are there in each stage? What is their importance? How many leaves should there be in each stage? How does the stem develop in the different stages?
4. Discuss cultivation practices used in the nursery garden:
 - Soaking and incubating technique: duration, replacement of water...
 - Soil preparation technique: preparing the bed, size of the bed...
 - Fertilizer use : type of fertilizer, amount and method of applying fertilizer
 - Sowing technique: amount of seed, method of sowing, covering bed with straw/rice husk
 - Watering technique: number of water applications and method of watering
 - Management of herbivores and natural enemies in the nursery
5. What cultivation methods should we apply in the nursery garden? Why?
6. How do you pull and transport tomato seedlings?
7. From your observations and discussions with farmers, what practices do they do in this stage? For what reasons?

1 - 7 days after transplanting

Objectives:

- Explain how the tomato plant recovers and develops after transplanting
- Compare speed of root and leaf formation
- Discuss cultivation methods which increase survival of tomato plants after transplanting

Duration :

120 min.

Materials:

Plants at 1 DAT, 3 DAT and 7 DAT

Magnifying glass, large paper, crayon, pencil

Method:

- * Collect plants from the field
- * Draw and describe different parts of the plants at different ages. Observe new root formation, places that roots occur, colour of roots, number of roots, length of roots.
- * Observe new leaf formation.

Discussions:

1. Comment on plant development: plant height, number of roots, number of leaves.
2. Why is it important to compare the speed between root and leaf formation?
3. What is the nutrient requirement of plants in this stage?
4. What cultivation practices can you apply in this stage to increase survival of tomato plants after transplanting? Discuss about soil preparation, basal dressing, watering, planting...
5. How many days does it take for the tomato plant to recover from transplanting?
6. How does the weather influence this stage?

7 - 22 days after transplanting

Objectives:

- Discuss plant development at vegetative and reproductive stages
- Discuss cultivation practices necessary at this stage

Duration:

90 minutes

Materials:

Plants at 8 - 10 DAT and 22 DAT, 5 flowers of tomato
Large paper, magnifying glass, crayon

Method:

- * Collect plants and flowers
- * Draw and describe morphology of the different parts of tomato plants at 8 DAT and 22 DAT

Discussions:

1. Comment on the plant development: plant height, leaf length, number of leaves in these 2 stages.
2. How many days after transplanting does the plant have the first bunch of flowers? How many leaves are there on the plant at that time? Where do the flowers develop?
3. How many flowers are there per bunch? What is the significance of the first bunch of flowers?
4. What is the function of the flower parts?
5. What are the nutrient requirements of the plant in this stage and what cultivation practices are needed? What type, how much and how should fertilizer be applied? Is it necessary to water? What method of watering should be used?
6. What factors influence the development of fruits in this stage?
7. How do you prune the plants? Why? Set up a small field study to find out.
8. What cultivation practices are farmers doing in this stage? Why?

Profuse flower and fruit stage

Objectives: Explain:

- characteristics of tomato plant from 22 DAT to profuse flower and fruit stage
- effect of different factors on the plant in this stage
- methods to increase fruit setting and fruit quality

Duration:

120 minutes

Materials:

Large paper, pencil, crayons

Tomato plants at 2 stages:

- at stage of first fruit set
- at stage of profuse flower and fruit

Method:

- * Pull 2 tomato plants of each of the 2 stages from the field
- * Observe, draw, describe morphological characteristics.

Discussions:

1. Comment on the plant development in this stage? What is its significance?
2. Comment on vegetative and reproductive growth in this stage?
3. What are the characteristics of the flower after pollination? What factors affect pollination?
4. What is the order of flower formation? How many flower sets were there on the plant? How many flower sets are necessary and sufficient to obtain high yield?
5. What is the role of water and fertilizer in this stage? Why?
6. When do you put support for tomato plants in the field?
7. What is the farmers' recommendation for putting support in the field?

Harvest stage

Objectives: Discuss:

- characteristics of tomato plant in harvest stage and form of ripe fruit (economical and physiological ripeness)
- factors that affect tomatoes in harvest stage

Duration:

120 minutes

Materials:

Plant with ripe fruits

Large paper, crayons, knife

Method:

- * Collect plants with ripe fruit from the field
- * Observe, draw, describe plant and fruit form. Also dissect the fruit and make observations.

Discussions:

1. What are the characteristics of plants at harvest stage?
2. What is the so-called economical and physiological ripeness?
3. What percentages of fruits were economically ripe in your field?
4. Is it necessary to apply cultivation methods (watering, dressing..) after each harvest when there are still fruits on the plants?
5. Comment on anatomy of the young and ripe tomato fruit? What factors affect red pigment formation (Caroten) in the fruit?
6. What herbivores are present?
7. What is the role of natural enemies in this stage?
8. What is the effect of growth stimulators? Why?