Field Guide on PEANUTS

National IPM Program Vietnam

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Background

Nam Thinh and Dien Hoa are villages within three kilometers distance of each other in the district of Dien Chau, Nghe An province. In Nam Thinh, 130 hectares are planted to peanuts. Dien Hoa grows peanuts in 120 hectares. Peanuts are produced in these two villages mainly for export to other countries. In Nam Thinh, peanuts are grown from February to July. This crop is followed by sesame which is grown for 80 days. The third season is used for maize, vegetables or sweet potato. In Dien Hoa, peanuts are also grown in the winter-spring season. After which, farmers grow two seasons of rice.

In 1995, researchers from the National Institute for Plant Protection (NIPP) and the International Crops Research Institute for the Semi Arid Tropics (ICRISAT) rented the fields of two farmers to conduct some field studies in the village of Nam Thinh. NIPP and ICRISAT did studies on fertilizer, seed treatment with fungicides, mixed cropping, different lime applications, use of growth stimulator and no use of pesticides on peanuts. In the same year, a rice field school on IPM was organized by the Provincial Sub Plant Protection Department in Dien Hoa. This involved 28 farmers. Because of the success that the farmers saw in IPM in rice, the farmers have decided to ask support from the Sub PPD to try out IPM in peanuts. The Sub PPD in turn requested assistance from the National IPM Program.

In response to this request, in January 1996, the National IPM Group worked with trainers from the Provincial Sub PPD of Nghe An and farmers from the villages Nam Thinh and Dien Hoa to formulate a proposal for a farmers’ study group on peanuts. At the national level, a series of discussions have been held between ICRISAT, NIPP and the national IPM program as to how the institutions can strengthen collaboration and complement field level activities on peanuts. The Field Guide on Peanuts is an illustration of the cooperation between these institutions.

This Field Guide was compiled by Almalinda Morales-Abubakar, Training Officer, FAO Programme for Community IPM in Asia, 2000
**General Introduction**

From discussions with farmer groups that attended a Farmer Field School we learned that in many cases the groups are interested in continuing activities and studies. One of the areas that farmer groups are interested to study more is peanuts. In this field guide field studies and special topics on varieties, fertilizer and compensation are explained. This field guide was developed with the inputs of IPM farmers, IPM trainers, the National IPM programme, the FAO IPM programme, the National Institute for Plant Protection (NIPP), and the International Crops Research Institute for the Semi Arid Tropics (ICRISAT).

Before starting any kind of activity after an FFS it is very important to discuss with the whole group what the most important problems in agriculture are in the village, and based upon that to decide what kind of follow up activity would be most useful in the village. If the farmer group considers plant development and/or evaluation of varieties as one of their most important problems, the farmers can then set up study fields to understand more about plant development and variety evaluation. The field guide is a material to help farmer go through these studies reinforced by discussions on special topics and weekly exercises. The field guide is intended for a first season of studies in which the group will meet one morning every week. The group can make a plan at the end of the season to decide how to continue in the following seasons.

In this season, we will focus on learning more about plant development and the methods that can be used to grow healthy crops beginning with the selection of appropriate varieties and sound cultivation practices. We will learn more about the peanut ecosystem and how its components interact because we believe that this is important in making good management decisions particularly about pest problems. We will also do simple exercises to better understand the role of insects in the ecosystem and try out ways of protecting them. During this field season, the group will conduct main studies, which will be supported by weekly exercises or mini-studies to learn more about the crop and issues related to its development.

The main studies to be undertaken are:

- Study 1: Management
- Study 2: Variety evaluation
- Studies 3, 7, 10, 12: Fertilizers
- Study 4: Use of trap crops
- Studies 5, 6, 8: Compensation
- Study 9 and 11: Cultural practices

Use of experiences gained from the activities should help bring farmers a better income by allowing them to improve their decision making about varieties, fertilizers, pesticides and a broader range of cultivation practices.

**Overall Objectives:**

1. To gain better knowledge and understanding of the development of peanuts
2. To explore various ways of better managing pests
3. To diversify and improve the set of peanut varieties available
4. To increase farmers' knowledge on disease management
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Field Studies
Study 1: Effect of different management methods on the ecosystem of peanuts
(This study will also be used for the simulation study on damage of aphids on plants in the 3-4 leaf stage)

Introduction:
In Vietnam, peanuts are grown with relatively high use of pesticides, i.e., on the average four sprays per season which are done in the first two months for defoliators. However, lately, reduction of pesticides in peanut growing has been getting a lot of attention. For instance, India now produces peanuts with strongly reduced or even no pesticide use. Farmers have been able to use IPM methods like cultural practices to manage pests for which they were previously using much pesticides. For example, in India, farmers doing IPM use trap crops like sunflowers or mungbeans. Trap crops are grown between peanut plants (1:100 for sunflowers and 6:100 for mungbeans) and are more attractive for Spodoptera than peanuts are. The Spodoptera lay their eggs on the trap crops which farmers can then collect and destroy. This way, their populations on peanuts remain low. There are other examples of IPM methods which we will try in this study. Furthermore, in this study yield, disease and pest and natural enemy populations on peanuts under IPM (based on ecosystem analysis), without pesticides, and under Farmers’ Practice will be monitored.

Objectives:
• Compare the disease incidence, natural enemy and pest populations for different management systems:
  + Farmer practice, based on the management practices that farmers use in the area
  + IPM - based on weekly ecosystem analysis; with trap crops, i.e., sunflower and mung beans
  + No pesticides
• Compare the economic benefits of the different management methods

Material:
Area for study: 900 m²
Variety: Common variety with medium growth duration
Materials for study: Hoe, shovel, trap crops, e.g., sunflower and mung beans
Fertilizer: Based on fertilizer use in the location for the season

Method:
* The study is set up with 3 treatments, 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 300 m² each. (See illustration below.)

<table>
<thead>
<tr>
<th>T1: farmer’s practice</th>
<th>T2: ecosystem analysis (IPM) with trap crops, i.e., sunflower and mung beans</th>
<th>T3: unsprayed</th>
</tr>
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* 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.
* Install pitfall traps on the evening before field sampling. (In these traps, you collect ground predators that are sometimes difficult to find during the day.) Use a cup with straight sides and about 12 cm height and 6 cm diameter. Bury the cup up to the lip in the soil, usually between two plants. Live predators can be collected if no water is placed inside the cup. However, if numbers of predators are to be assessed, place water mixed with some liquid detergent to collect all insects that fall into the cup. Check the cups in the morning after leaving it overnight. Predators caught in pitfall traps will help complement the visual counts of predators during field sampling.
* Check the under sides of sunflower leaves weekly for egg masses or for brown marks made by newly emerged catterpillars. Destroy eggs or larvae physically.

2 field guide exercises for ipm in peanuts
* Observe and analyse ecosystem every 7 days using questions in the section on ecosystem.

**Sampling:**
Weekly:
◊ Observe 10 fixed plants per treatment for plant development: height of plant, number of green and yellow leaves, number of branches, number of flowers, number of tubes, number of full tubes, number of seeds per tube, color of seeds
◊ Assess the uniformity of plant growth, weather condition and the general situation of the field
◊ Observe pest and natural enemy density as well as disease intensity
Measure yield at harvest
Collect data throughout the season for economic analysis

**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. How were the yields in each of the treatments?
2. What management practices are important in growing peanuts (cultivation practices, fertilizer management, watering, etc.)?
3. What natural enemies were there in the peanuts field? What is their significance? How do you protect them and also limit the damage of pest?
4. What pests occurred in the peanuts field? Which was the most important in each stage? How do you control them and also protect natural enemies?
5. How many times did the farmer spray pesticide? Was it necessary? What was the effect of pesticide use on natural enemies?
6. Which management method was most economic? Why? Was there a difference in quality of peanuts in the different treatments? What about the cost per treatment?
7. What further studies do you recommend to better understand the ecosystem of peanuts?
8. What is the role or function of the sunflower?
Study 2: Evaluation of peanut varieties
(This study may be of particular importance in the North. However, in the South farmers may not find it necessary.)

Introduction:
Many varieties exist with different characteristics in production. For any farmer it is important to know which variety has high yield, good quality and is popular in the market. In the field, farmers often face many difficulties such as diseases, pest insects, cultivation conditions and costs of production. These can be different in each location. In this study, you, the farmers will decide for yourselves how well suited varieties might be for peanuts production in your location based on certain criteria as compensation ability, yield, seed quality, etc.

Objective:
Test the performance of different peanut varieties under local conditions using IPM management methods

Materials:
Area for study: 700 m²
Number of varieties: The number of varieties will depend on what is locally available. However, a maximum of four varieties is recommended.
Material 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., 4 peanut varieties. The 4 treatments will be replicated 3 times. The plot size of each replication is 50m².
* Field Management: will be based on weekly agroecosystem analysis

Sampling:
Weekly:
◊ Sample 10 fixed plants/plot for plant development: height of plant, number of green and yellow leaves, number of branches, number of flowers, number of tubes, number of full tubes, number of seeds per tube, color of seeds
◊ Assess the uniformity of plant growth, weather condition and the general situation of the field
◊ Observe pest and natural enemy density as well as disease intensity
Measure yield at harvest including weight per 1000 seeds
Collect data throughout the season for economic analysis

Results:
1. Plot plant development of the varieties tested
2. Plot herbivore populations for each variety
3. Plot natural enemy populations for each variety
4. Plot yield of the different varieties
5. Summarize all management practices for each treatment (fertilizer, pesticides, etc)

Discussions:

4 field guide exercises for ipm in peanuts
1. How was the plant development in each of the treatments?
2. Was the quality of the peanuts for each variety the same?
3. Which variety had the highest yield? Which the lowest?
4. Which variety is easy to sell? Was there a difference in market prices?
5. Where there differences in herbivore populations between the varieties in different development stages of the peanuts?
6. How was the composition and population density of natural enemies on each variety?
7. Is disease developing in the same way on all varieties? Are there some varieties that have little infection and that remain like that compared to the weeks before? Is the disease getting worse on some varieties? What does this mean for management of diseases?
8. Was variety the most important factor in peanuts production?
9. Which variety you think would be the most suitable for this region? If you were a farmer, which variety would you choose? Why? Is any one variety obviously the best? Or do different varieties have different advantages?
Study 3: Yield, pest and natural enemy, and disease response to fertilizer

Introduction:
Fertilizer is a very important element affecting the peanut crop. Adding organic fertilizer to the soil will improve the soil structure, which is important in peanut growing. Often chemical fertilizer is added to obtain high yields. In this study we will evaluate the yield, pest and natural enemy response to different fertilizer applications. However, since chemical fertilizer application is mainly the same for peanuts in this location, we shall focus on different manure levels in this study.

Objectives:
- Try out different manure levels for peanuts, to obtain high yield and good quality and economic benefits
- Explain the effect of different manure levels on composition and density of natural enemy and pest populations, and disease incidence in the peanut field

Materials:
Area for study: 700 m$^2$
Variety: Select the peanut variety that is most commonly used locally. Plant density depends on variety and region.
Materials for study: Hand sprayer, hoe, shovel
Fertilizer: Manure, Urea, Potassium, Phosphate

Method:
- The study is set up with 4 treatments, i.e., 4 levels of manure application. The 4 treatments will be replicated 3 times in plot size of 50 m$^2$ each. Assign treatments to plots randomly.
- NPK will be based on farmers practice
- Treatments:
  - Treatment 1: 3 tons of manure per hectare
  - Treatment 2: 6 tons of manure per hectare
  - Treatment 3: 9 tons of manure per hectare
  - Treatment 4: 12 tons of manure per hectare
- Field Management: will be based on ecosystem analysis. However, when disease occurs, split plots to observe disease incidence. Spray half and keep half of the field unsprayed. Use fungicides such as Daconil, Bavistin, M45 on half of each plot when the first leaf spot lesions appear on the lower leaves and 10 days later unless the second spray comes within 10 days of harvesting.
- Method of application of manure: will be based on the normal farmers' practices in the area

Sampling:
Weekly:
- Sample ten fixed plants/plot for plant development: height of plant, number of green and yellow leaves, number of branches, number of flowers, number of tubes, number of full tubes
- Observe weather condition and general field situation
- Assess natural enemy, pest populations and 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 disease incidence for each treatment
5. Plot yield for each treatment
6. Make economic analysis for each treatment
Questions:
1. What was the effect of different manure levels on plant development?
2. What differences did you observe on the natural enemy, pest populations and disease incidence in each treatment? Why were there differences?
3. Is disease developing in the same way on all treatments? Are there some treatments that have little infection and that remain like that compared to the weeks before? Is the disease getting worse on some treatments? What does this mean for management of diseases?
4. What treatment gave the highest yield? Which treatment was the most economic? Which level you think a farmer would like to use? Why?
5. Which of these treatments can you apply to your field to get the best results?
6. Why do you think it is not possible to use only one recommendation for manure levels for the whole village? What factors should be considered?
7. Is it necessary to continue these studies in the future? Do you have ideas on what to look at in the next season?
Study 4: Use of trap crops

**Introduction:**
Growth duration of different crops can be very different. Farmers often grow more than one kind of crop in the same plot, to better use the land, and to obtain higher income. However, this study will focus on the effect of mono cropping and mixed cropping on peanuts development and ecosystem. In particular, sunflower and mung beans will be used as trap crops for Spodoptera and aphids respectively.

**Objectives:**
- Compare the ecosystem of peanuts grown as monoculture with peanuts grown mixed with either sunflowers or mung beans
- Identify suitable mixed cropping systems for the location, particularly for use as attractants/trap crops for insects which may cause damage to crops

**Material:**
Area for study: 600 m$^2$
Variety: Most popular peanut variety in the location. Plant density depends on what is common in the study area
Materials for study: Hand sprayer, hoe, shovel, sunflower (1:100) and mung beans (6:100)
Fertilizer: Based on fertilizer use in the location

**Method:**
- The study is set up with four treatments, i.e., two mixed crops and two mono crops. The 4 treatments will be replicated three times. The plot size of each replication is 50 m$^2$. Assign treatments randomly to the plots.
- Treatments:
  Treatment 1: Peanuts + Sunflower
  Treatment 2: Peanuts + Mung beans
  Treatment 3: Peanuts + Sunflower + Mung beans
  Treatment 4: Peanuts only
- Plant other crops a week after seeding peanuts. In the North, plant sunflowers again a month after seeding.
- The ratio of sunflower to peanut plants is 1:100. For mung beans, use the ratio 6:100. The trap crops may be planted between the peanuts. (Note: To plant sunflowers, select the good seeds; make planting holes and use three seeds for each hole.)
- Field Management will be based on IPM. However, since the study is on the use of trap crops, no pesticides will be used.
- Check the under sides of sunflower leaves weekly for egg masses or for brown marks made by newly emerged catterpillars. If bird perches are being used, collect the eggmasses and drop these into the tube. Otherwise, destroy eggs or larvae physically.

**Sampling:**
Weekly:
- Sample 10 fixed peanut plants, three sunflower plants and three mung bean plants in each plot for plant development: height of plant, number of green and yellow leaves, number of branches, number of flowers, number of tubes, number of full tubes
- Assess the uniformity of plant growth, weather condition and the general situation of the field
- Observe pest and natural enemy density as well as disease incidence
- Measure yield at harvest
Collect data throughout the season for economic analysis

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8 field guide exercises for ipm in peanuts
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. Summarize all management practices for each treatment
6. Make economic analysis for each treatment

Questions:
1. How is the plant development in each of the treatments? How did trap crops influence plant development?
2. What differences did you observe on the ecosystem between mono cropping and fields with trap crops? Discuss natural enemy, pest populations, disease incidence, weeds in each treatment.
3. What treatment gave the highest yield? What treatment is giving the highest profit for the farmer? Is sowing trap crops worth while or not? Why or why not?
4. What cultivation methods should be paid attention to to guarantee that both peanuts and the other crop/s develop well?
5. Are farmers in this area normally using mono or mixed cropping systems? Why?
6. How can you apply this study in your own field and in the community?
7. What is the role or function of the sunflower? Why should farmers regularly collect eggmasses and larvae on the sunflower?
8. Will you grow sunflower in your field? How will you convince other farmers in your village to grow sunflowers with their peanut crop?
9. Is it necessary to continue these studies in the future? Do you have ideas on what to look at in the next season?
Study 5: Compensation of plant for damage - Leaf cutting

Introduction:
Often a healthy crop can compensate for some damage that occurs. It is important to understand what kind of damage can be compensated for and what kind of damage will result in yield loss. This study will find out what happens when defoliation of 25%, 50% and 75% occurs at various stages.

Objective:
Test the ability of peanut plants to compensate for damage of leaves

Material:
Area for study: 100 m²
Variety: Most common peanut variety in the study area
Materials for study: Hand sprayer, hoe, shovel, knife/scissors
Fertilizer: Based on fertilizer use in the location

Method:
* The study is set up with 10 treatments in ten plots measuring 10 m² each.
* Defoliate 10 plants per plot
* Way to defoliate: Cut across leaf (Note: See illustration of peanut plant.)

Time of defoliation:
* At 30-35 days after seeding
  Treatment 1: cut 25% (1/2 of two leaflets) of a compound leaf
  Treatment 2: cut 50% (1/2 of all four leaflets) of a compound leaf
  Treatment 3: cut 75% (two whole leaflets and 1/2 of two leaflets) of a compound leaf
* At full flowering stage (50-55 days)
  Treatment 4: cut 25% (1/2 of two leaflets) of a compound leaf
  Treatment 5: cut 50% (1/2 of all four leaflets) of a compound leaf
  Treatment 6: cut 75% (two whole leaflets and 1/2 of two leaflets) of a compound leaf
* At tube development stage (60-70 days)
  Treatment 7: cut 25% (1/2 of two leaflets) of a compound leaf
  Treatment 8: cut 50% (1/2 of all four leaflets) of a compound leaf
  Treatment 9: cut 75% (two whole leaflets and 1/2 of two leaflets) of a compound leaf
  Treatment 10: Control

Field Management will be based on farmers’ practices in the location.

Sampling:
Weekly:
◊ Sample three fixed plants/plot for plant development: height of plant, number of green and yellow leaves, number of branches, number of flowers, number of tubes, number of full tubes
◊ Observe weather condition and general field situation
◊ Assess natural enemy, pest populations, and disease incidence
Measure yield at harvest

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 and economic benefits for each treatment
Questions:
1. How did the plant compensate with the defoliation at 3-4 leaf stage? at full flowering? at tube development? compared to the control?
2. What differences did you observe on the natural enemy, pest populations, disease incidence, weeds in each treatment? Why were there differences?
3. What treatment gave the highest yield? What is the effect on yield if peanut leaves have been eaten in different development stages?
4. How can the farmer use the results of the study for making management decisions in his field?
Study 6: Compensation of plant for damage - Removal of plants

Introduction:
Peanuts seeds are planted in holes and rows. When they are established, thinning or replanting is done depending on the density of the plants. In the field situation, sometimes plants obtain stem damage which accounts for loss of plants. This study will simulate damage to stems by removal of plants.

Objective:
Test the ability of peanut plants to compensate for damage of stem

Material:
Area for study: 150 m²
Variety: Most common peanut variety in the study area
Materials for study: Hand sprayer, hoe, shovel, knife/scissors
Fertilizer: Based on fertilizer use in the location

Method:
* The study is set up with 5 treatments in plots measuring 10 m² each. Three replications will be done per treatment.
* At 3-4 leaf stage, do the following treatments:
  Treatment 1: remove 5% of plants (remove one per twenty plants)
  Treatment 2: remove 10% of plants (remove one per ten plants)
  Treatment 3: remove 15% of plants (remove one per seven plants)
  Treatment 4: remove 20% of plants (remove one per five plants)
  Treatment 5: control
* Field Management will be based on farmers’ practice in the location.
* Way to remove plant: Pull out entire plant (including roots)

Sampling:
Weekly:
◊ Sample ten fixed plants/ plot for plant development: height of plant, number of green and yellow leaves, number of branches, number of flowers, number of tubes, number of full tubes
◊ Observe weather condition and general field situation
◊ Assess natural enemy, pest populations, and disease incidence
Measure yield at harvest

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 and economic benefits for each treatment

Questions:
1. How is the plant development in the different treatments compared to the control?
2. What differences did you observe on the natural enemy, pest populations, disease incidence, weeds in each treatment? Why were there differences?
3. What treatment gave the highest yield? What is the effect on yield if peanut plants are lost early on in the season?
4. How can the farmer use the results of the study for making management decisions in his field?
Study 7: Effect of liming application

Introduction:
In peanut growing areas, some farmers have observed that tube formation is enhanced and yields are increased when lime is applied as top dress. Other farmers have other observations. This may have something to do with the soil pH. And therefore, in some areas it is necessary to supplement lime to the soil, especially where soils have a low pH. However, farmers have different methods of applying lime. In this study we will compare crop development, pest and disease intensity and yields in plots with lime applied in different methods.

Material:
Area for study: 500 m²
Variety: Most popular peanut variety in the location.
Materials for study: Lime based on FP at the rate of 30kg/hectare, hoe, shovel
Fertilizer: Based on fertilizer use in the location for three different treatments

Method:
* The study is set up with 3 treatments replicated three times. The plot size for each replication is 50 m². Assign treatments randomly to the plots.
* Treatments:
  Treatment 1: Use lime only as basal fertilizer
  Treatment 2: Use 70% of the lime as basal fertilizer and 30% as top dress at full flowering
  Treatment 3: Use lime only as top dress at full flowering
* Field management will be based on ecosystem analysis.

Sampling:
Weekly:
◊ Sample 10 fixed peanut plants for plant development: height of plant, number of green and yellow leaves, number of branches, number of flowers, number of tubes, number of full tubes, number of seeds per tube
◊ Assess the uniformity of plant growth, weather condition and the general situation of the field
◊ Observe pest and natural enemy density as well as disease incidence
Measure yield at harvest including weight per 1000 seeds.
Collect data throughout the season for economic analysis.

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. Summarize all management practices for each treatment
6. Make economic analysis for all treatments

Questions:
1. How is the plant development in each of the treatments?
2. What differences did you observe on the natural enemy, pest populations, disease incidence, weeds in each treatment? Why were there differences?
3. Was applying lime in this study worth while or not according to you? Why or why not? How much should be applied?
4. Which of the treatments gave more filled and better looking tubes?
5. What treatment gave the highest yield? What treatment is giving the highest profit for the farmer?
6. How can you apply this study in your own field and in the community?

Study 8: Simulation of damage by young leaf feeders

13 field guide exercises for ipm in peanuts
The study will be implemented in the same plots being used for the Effects of Different Management Methods on the Ecosystem of Peanuts.

Introduction:
Often a healthy crop can compensate for some damage that occurs. It is important to understand what kind of damage can be compensated for and what kind of damage will result in yield loss.

Objective:
Test the ability of peanut plants to compensate for damage of leaves

Material:
Area for study: 6 m² (in the same plots being used for the study on Effect of Different Management Methods on the Ecosystem of Peanuts)
Variety, Materials for study, and Fertilizer: see Study 1- Management Methods

Method:
* The sub-study is set up with 2 treatments in plots measuring 1 m² each. Each treatment is replicated three times.
* Time of defoliation: At 3-4 leaf stage
* Treatments:
  Treatment 1: remove all young leaves
  Treatment 2: control (no removal of leaves)
* Way to defoliate: Cut all leaves of plants in the 1 m² sub-plots
* Field Management: see Study 1: Management Methods

Sampling:
Weekly:
◊ Sample three fixed plants/plot for plant development: height of plant, number of green and yellow leaves, number of branches, number of flowers, number of tubes, number of full tubes
◊ Observe weather condition and general field situation
◊ Assess natural enemy, pest populations and disease incidence
Measure yield at harvest

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 and economic benefits for each treatment

Questions:
1. Compare plant development between treatments. How did the plant compensate with the defoliation at 3-4 leaf stage compared to the control?
2. What differences did you observe on the types and populations of pest and natural enemy in each treatment? Why were there differences?
3. Compare disease incidence and development.
4. What treatment gave the highest yield? What is the effect on yield if all peanut leaves have been eaten in the 3-4 leaf stage?
5. What insects eat peanut seedlings? If you see the same kind of insects in your field, what will you do?
6. How can the farmer use the results of this study for making management decisions in his field?
Study 9: Effect of earthing up on peanuts

Introduction:
Some farmers practice earthing up at the second time of flower shedding. The reason for this practice is for deeper soil penetration of the flower stalk and to facilitate tube formation. Other farmers think loosening the soil is enough and may even give a better yield than the earthing up method. This study will compare the results of peanuts grown with and without earthing up.

Objective:
Compare plant development, natural enemy and pest populations, yields and economics of peanuts grown with and without earthing up

Material:
Area for study: 400 m²
Variety, Materials for study, and Fertilizer: see Study 1- Management Methods

Method:
* The study is set up with 2 treatments in plots measuring 50 m² each. Each treatment is replicated three times.
* Treatments:
  Treatment 1: earthing up at 2nd flower shedding
  Treatment 2: control (no earthing up)
* All other cultivation methods: based on farmer’s practice
* Field Management: based on IPM

Sampling:
Weekly:
◊ Sample 10 fixed plants/plot for plant development: height of plant, number of green and yellow leaves, number of branches, number of flowers, number of nodes, number of tubes, number of full tubes
◊ Observe natural enemy, pest populations and disease incidence
Measure yield at harvest

Results:
1. Plot plant development for each treatment.
2. Plot herbivore and natural enemy populations for each treatment
3. Plot disease incidence for each treatment
4. Plot yield for each treatment
5. Compute for economic benefits

Questions:
1. Compare plant development between treatments.
2. What differences did you observe on the composition and populations of pest and natural enemies in each treatment? Why were there differences?
3. Compare disease incidence and development.
4. Compare occurrence of weeds between treatments.
5. What treatment gave the higher yield? What do you think about earthing up?

Study 10: Effects of different dosage of lime on peanuts
Introduction:
Lime application reduces the acidity of soil which has a direct effect on enhancing plant development. In some areas it may be necessary to apply lime to the soil especially where soils have a low pH. However, the suitable lime dosage for plant development depends on the type of soil in the locality. In this study we will compare crop development, pest and disease intensity and yields in plots with different dosage of lime.

Objective:
Compare the effect of different lime dosage on yield, pests, natural enemy and disease

Material:
* Area for study: 600 m²
* Variety: Common variety with medium growth duration
* Materials for study: Hoe, shovel
* Fertilizer: Other fertilizer based on use in the location for the season; lime based on treatments below-mentioned

Method:
* The study is set up with 4 treatments in plots measuring 50 m² each. Each treatment is replicated three times.
* Treatments:
  Treatment 1: 200 kg of lime per hectare
  Treatment 2: 400 kg of lime per hectare
  Treatment 3: 600 kg of lime per hectare
  Treatment 4: 800 kg of lime per hectare
* Application method: 70% of lime as basal; 30% as top dress at second flower shedding
* Planting density and cultivation method: based on local methods
* Field Management: based on IPM

Sampling:
Weekly:
◊ Sample 10 fixed plants/plot for plant development: height of plant, number of green and yellow leaves, number of branches, number of flowers, number of nodes, number of tubes, number of full tubes, number of seeds per tube, color of seeds
◊ Observe climate, weather and plant uniformity
◊ Observe natural enemy, pest populations and disease incidence
Measure yield at harvest

Results:
1. Plot plant development for each treatment.
2. Plot herbivore and natural enemy populations for each treatment
3. Plot disease incidence for each treatment
4. Plot yield and economic benefits for each treatment

Questions:
1. Compare plant development between treatments.
2. Compare the color of seeds between treatments.
3. What differences did you observe on the composition and populations of pest and natural enemies in each treatment? Why were there differences?

4. Compare disease incidence and development.
5. Compare occurrence of weeds between treatments.
6. What treatment gave the highest yield? Which gave the highest economic benefits?
7. Which dosage is used in your locality? Which dosage of lime will you apply in your own field next season? Why?
Study 11: Influence of planting density on peanuts

Introduction:
Planting density affects branch development to a great extent. If planting density is high, the plants will not produce many branches and the yield will be reduced. On the other hand, if planting density is low, the plant will produce many branches and there will be many flowers but we may not be maximizing benefits we can obtain for the soil from planting peanuts. Different kinds of soils require different suitable planting densities. This study will show the influence of different planting densities on different kinds of soil on pests, natural enemy, disease and yield.

Objective:
Compare the effect of different planting densities on different kinds of soil on pests, natural enemy, disease and yield

Material:
* Area for study: 700 m²
* Variety: Common variety with medium growth duration
* Materials for study: Hoe, shovel
* Fertilizer: Based on use in the location for the season
* Field management: Based on IPM

Method:
* The study is set up with 5 treatments in plots measuring 50 m² each. Each treatment is replicated three times.
* Treatments:
  Treatment 1: based on FP
  Treatment 2: based on FP; reduce by 5 plants/m²
  Treatment 3: based on FP; reduce by 10 plants/m²
  Treatment 4: based on FP; increase by 5 plants/m²
  Treatment 5: based on FP; increase by 10 plants/m²
* All other practices: based on farmer’s practice
* Field Management: based on IPM

Sampling:
Weekly:
◊ Sample 10 fixed plants/plot for plant development: height of plant, number of green and yellow leaves, number of branches, number of flowers, number of nodes, number of tubes, number of full tubes, number of seeds per tube, color of seeds
◊ Observe climate, weather and plant uniformity
◊ Observe natural enemy, pest populations and disease incidence
Measure yield at harvest

Results:
1. Plot plant development for each treatment.
2. Plot herbivore and natural enemy populations for each treatment
3. Plot disease incidence for each treatment
4. Plot yield and economic benefits for each treatment

Questions:

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1. Compare plant development between treatments.
2. Compare the color of seeds between treatments.
3. What differences did you observe on the composition and populations of pest and natural enemies in each treatment? Why were there differences?
4. Compare disease incidence and development.
5. Compare occurrence of weeds between treatments.
6. What treatment gave the highest yield? Which gave the highest economic benefits?
7. Which density is similar to the one used in your locality? Which density will you apply in your own field next season? Why?
Study 12: Influence of dosage of Phosphate on peanuts

Introduction:
Fertilizer is a very important element affecting the peanut crop. Specifically, adding phosphate increases yields and improves the quality of peanuts. In this study we will evaluate the influence of different dosage of phosphate on yield, pests, natural enemy and disease of peanuts.

Objective:
Evaluate the influence of different dosage of phosphate on yield, pests, natural enemy and disease of peanuts

Material:
∗ Area for study: 700 m²
∗ Variety: Common variety with medium growth duration
∗ Materials for study: Hoe, shovel
∗ Fertilizer: Based on use in the location for the season; phosphate as indicated in treatments below

Method:
∗ The study is set up with 4 treatments in plots measuring 50 m² each. Each treatment is replicated three times.
∗ Treatments:
  Treatment 1: 300 kg Phosphate per hectare
  Treatment 2: 400 kg Phosphate per hectare
  Treatment 3: 500 kg Phosphate per hectare
  Treatment 4: control
∗ Planting density and cultivation method: based on local methods
∗ Field Management: based on IPM method

Sampling:
Sample 10 fixed plants/plot weekly for:
◊ Plant development: height of plant, number of green and yellow leaves, number of branches, number of flowers, number of nodes, number of tubes, number of full tubes, number of seeds per tube, color of seeds
◊ Observe climate, weather and plant uniformity
◊ Assess natural enemy, pest populations and disease incidence
Measure yield at harvest

Results:
1. Plot plant development for each treatment
2. Plot herbivore and natural enemy populations for each treatment
3. Plot disease incidence for each treatment
4. Plot yield and economic benefits for each treatment

Questions:
1. Compare plant development between treatments.
2. What is the difference in color of seeds between treatments?
3. What differences did you observe on the composition and populations of pest and natural enemy in each treatment? Why were there differences?
4. Compare disease incidence and development between treatments.
5. Compare occurrence of weeds between treatments.
6. What treatment gave the highest yield? Which gave the highest economic benefits?
7. Which level of phosphate is similar to the one used in your locality? Which level will you apply for your own plots next season? If you use phosphate in this season, will that influence your decision on phosphate use for the next season? Why or why not?
Ecosystem Analysis Questions
Ecosystem

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

We need to start looking at the peanut ecosystem from the viewpoint of maximizing profits without destroying the system. We need to understand the interactions and components.

In this exercise we will look at the peanut system interactions.

Objective:
Demonstrate the function and balance of the components of the peanut ecosystem

Time required:
120 minutes

Materials:
Markers, glue, scissors, paper

Method (for groups of five persons):
1. Go to the peanut field for 30 minutes and record all kinds of plants, insects and spiders seen in the field. Use a net to catch more small insects and small wasps.
2. Return to the classroom and draw and write the names of things seen in the field on small paper (2x5 cm).
3. Add papers with names "sunshine", "rain", "high fertilizer", "low fertilizer".
4. Discuss with group members how the parts interact. Paste the drawings of the ecosystem compounds on the big paper, and draw lines between all the components which interact. Explain what the lines mean.
5. Next discuss the outcome of the following situations. Discuss what happens to each component over one season.
   a. A spray is used that kills all insects and spiders. Then pests migrate to the field.
   b. The plant is resistant to all pests, so that no pest is in the field. What happens?
   c. The plant has high fertilizer and sunny conditions.
   d. The plant has high fertilizer and rainy cloudy conditions.
   e. The plant dies.
6. Present your group’s discussion to other groups.
Ecosystem Analysis

Introduction:
Decision making in IPM requires an analysis of the ecosystem. We have seen how sampling, and thresholds are important parts of that analysis. We have also discussed how some parts of the ecosystem interact. Now we will begin to use a method of Ecosystem Analysis to facilitate discussion and decision making.

The Ecosystem analysis will be done weekly, following monitoring activities and studies of components of the peanut ecosystem. The results of the field observations will be drawn on a large piece of paper using specific rules given below. The drawing will then be used for discussion. There are questions designed for discussion during each stage of the crop. After discussion it is important that the results are presented to other groups. Everyone should be involved in the observations, drawing, discussion and presentation. Changing the person who gives the presentation each week is important to keep everyone involved.

Objectives:
Analyze the field situation by observation, drawing, and discussion
Make decisions about any action/s required in the field

Time required:
120 minutes

Materials (per group):
One piece notebook paper, one large size paper, pencil and drawing crayons.

Method:
1. Go to the field. Walk across the field and choose 10 plants. For each plant follow this examination process and record your observations. This should be done for each plot.

   Plants: measure plant size. Count leaves (green, yellow).

   Insects: observe and count at the different places on the plants the different pest insects.

   Disease: look at leaves and stems. Observe lesions caused by diseases, and count the number of leaves with disease. Estimate the percentage of leaf area infected.

   Natural enemies: count the number of each type of predator and the number of larvae with parasites. Also collect insect from pitfall traps. (See page ___ for instructions on pitfall traps.)

   Rats: count number of plants affected by rats.

   Weeds: count different weeds in the field.

   Water situation: observe and record the water situation in the field.

   Weather: record last week's weather situation.

2. Find a shady place to sit as a group. Each group should sit together in a circle, with pencils, crayons, data from each of the field activities (IPM, FP, No spray), and the drawing of the ecosystem of the previous week.

3. Now make a drawing on the large piece of paper. Everyone should be involved in the drawing. Make a drawing for each plot observed. There are several rules for drawing as follows:

   Draw the plant with the correct numbers of leaves, flowers, fruits. Write the plant height, number of green and yellow leaves somewhere. If the plant is healthy, colour the plant green. If diseases occur, draw the disease. If the plant is yellow, colour it yellow.
Draw dead or dying leaves in yellow.

For weeds, draw the approximate density and size of weeds in relation to the size of the peanut plant. Draw the kinds of weed in the field.

For pest populations, draw the different insects found in the field on the right side of the plant. Write the average number next to the insect. Also write the local name next to the insect. The data can also be summarized in a table on the right side.

For natural enemy populations, draw the insects and spiders as found in the field on the left side of the plant. Write the average number of natural enemies and their local names next to the drawing.

For rats, write the average number of plants/fruit attacked.

If the week was mostly sunny, add a sun. If the week was mostly sunny and cloudy together, draw a sun but half covered with dark clouds. If the week was cloudy all day for most of the week, put just dark clouds.

If the field was fertilized, then place a picture of a hand throwing N, P or K into the field depending on the type of fertilizer used.

If pesticides were used in the field, show sprays with a nozzle and write the type of chemical coming out of the nozzle. If granules were broadcast, show a hand with the name of pesticide being broadcast.

4. Keep your drawings for comparison with weeks later in the season.

5. Now discuss the questions listed below for each stage of the plant depending on the crop observed. One person in the group is designated as the questioner (change the person each week). This person will ask questions about the field. Write your answers on the paper and add a summary.

6. Each group should make a presentation of their field observations, drawing, discussions and summary. A different person should make the presentation each week.
I. Germination stage - 3 leaves

Objectives: Discuss:
• structure, morphology and function of each part of the peanut plant at stage of germination
• correlation between structure, morphology, function, cultivation and insects
• similarities and differences between peanut and rice plant (representative of one germ leaf plant) at germination stage

Method:
∗ Collect peanut plant at 3-leaf stage
∗ Observe plant development: plant height, roots, nodes, etc
∗ Make drawings

Discussions:
1. Weather: What is the weather like today (sunshine, rain, temperature, humidity ...)? Does the soil have enough or excess or lack of water? How does the weather affect peanut's ecosystem in this stage?

2. Plant: How many leaves are there on plant? Have branches appeared? What is the color of the leaves? Does the plant seem to lack nutrients? How do you expect the plants to develop next week?

3. Pest insects and natural enemies: What kinds of pest insects are occurring in the fields? What are their densities? Which is the most harmful? Are there many natural enemies in the fields? What is their ability to control the pest insects? How do you expect the population of pest insects and natural enemies to develop in the next days?

4. Diseases: What diseases are occurring in the fields? Are there many or just a few diseases? Which disease needs to be paid more attention to? How do you expect the diseases to develop in the next days?

5. Compensation ability: What is effect on the plant if its leaves and sprouts are eaten by insects? To what extent can the peanut plants compensate for defoliation and damage to stems? (Relate to removal of sprout and defoliation study.) To what extent can peanut plants compensate for diseases?

6. Management decisions: Is it necessary to apply more fertilizer? Is it necessary to water? Is it necessary to earth up? Is it necessary to weed? What do you do to manage insects: collect insect, eggmasses ...? What do you do to manage diseases? Should you continue to observe?
II. Branch formation stage

**Objectives:** Explain:
- plant’s ability to issue new leaves and show branches in the light of damage caused by diseases and insects like cutworm
- cultivation practices necessary in this stage

**Method:**
- Collect peanut plants at branch formation stage
- Observe plant development: plant height, number of leaves, branches, nodes, etc
- Graph plant development: plant height, number of leaves, branches, nodes, etc
- Make drawings

**Discussions:**
1. *Weather:* What is the weather like today (sunshine, rain, temperature, humidity ...)? Does the soil have enough or excess or lack of water? How does the weather affect the peanut's ecosystem in this stage?

2. *Plant:* How is plant height in comparison with last week? How many leaves are there on the plant? What color are they? Has the plant formed branches? How many branches are there? Where do they come from? What factors have a bearing on the emergence of branches: cropping density, weather, nutrition? Are there any buds and flowers? Does the plant seem to lack nutrients? How do you expect the plants to develop next week? Have you seen any nodules? What is the role of nodules to the soybean plant in particular and to the recultivation of the field in general?

3. *Pest insects and natural enemies:* What kinds of the pest insects are occurring in the fields? Are there many or just a few of them? Which is the most harmful? Are there many natural enemies in the fields? What is their ability in controlling the pest insects? How do you expect the population of pest insects and natural enemies to develop in the next days?

4. *Diseases:* What diseases are occurring in the fields? Are there many or just a few diseases? Which of the diseases should be paid more attention to? How do you expect the diseases to develop in the next days?

5. *Attractants/trap crops:* Did you grow attractants/trap crops? How is the development of the attractant/trap crop? Are there any insects, eggmasses on the attractant/trap crop? Compare the number of insects and eggmasses with that seen on peanut plants?

6. *Compensation ability:* What is effect on the plant if its leaves are eaten by insects at this stage? To what extent can peanut plants compensate for damage at this stage? (Relate to defoliation study.) Is the plant infected by diseases? To what extent can peanut plants compensate for damage caused by disease at this stage?

III. Flowering - flower stalk elongation stage

Objectives: Explain:
• changes in the plant from branch formation stage to flowering stalk elongation stage
• factors which determine the duration of the flowering stage
• cultivation practices which can be used in this stage so that the plant can produce good flowers and fruits

Method:
* Collect plants at flowering - flower stalk elongation stage and observe plant development: plant height, number of leaves, branches, etc.

Discussions:
1. Weather: What is the weather like today (sunshine, rain, temperature, humidity ...)? Does the soil have enough or excess or lack of water? How does weather affect the peanut's ecosystem in this stage?

2. Plant: How is plant height in comparison to last week? How many leaves are there on the plant? What color are they? How many branches are there on the plant? Where do the branches come from? Does the plant seem to lack nutrients? How do you expect the plant to develop next week? How many flowers are there on the plant? On which branches are there most flowers on? How do you think the flowers will develop next week? Do you think that the branches with the most flowers will also have the best seeds? How many flower stalks have elongated? On which branches are they forming? How do you expect flower stalks to develop next week? How many nodules are there? Are they small or big? What color are they? What is the role of nodules?

3. Insect pests and natural enemies: What kinds of pest insects are occurring in the fields? Are there many or just a few of them? Which is the most harmful? Are there many natural enemies in the fields? What is their ability in controlling the pest insects? How do you expect the population of pest insects and natural enemies to develop in the next days? Relate results of insect zoos to field observations.

4. Diseases: What diseases are occurring in the fields? Are there many or just a few diseases? To which disease should you pay more attention to? How do you expect diseases to develop in the next days?

5. Attractants/trap crops: How is the development of the attractant/trap crop plant? Are there any insects, eggmasses on the attractant/trap crop? Compare the number of insects and eggmasses on the attractant/trap crop to those on peanut plants.

6. Compensation ability: What is effect on the plant if its leaves are eaten by insects at this stage? To what extent can the peanut plant compensate for damage caused by diseases at this stage? (Relate to defoliation study.) Is the plant infected by diseases? To what extent can peanut plants compensate for damage caused by diseases at this stage?

7. Management decisions: Is it necessary to apply more fertilizer? Is it necessary to water? Is it necessary to earth up, cover the roots? Why? Is it necessary to weed? What do you do to manage insects: collect insects, eggmasses ...? What do you do to manage diseases? Is it necessary to collect insects and eggmasses on the attractants/trap crops? Why? What should be done to care for the attractants/trap crops? What will you do if your plot is flooded? Should you continue to observe?
IV. Pod formation and development stage

Objectives: Explain:
- process of fruit formation
- process of accumulation of dry substance and seed formation
- effect of different factors on the plant in this stage

Method:
- Collect peanut plants in pod formation and development stage
- Estimate numbers of tubes and seeds per tube
- Expose seeds, compare their color and draw their shapes

Discussions:
1. Weather: What is the weather like (sunshine, rain, temperature, humidity ...)? Does the soil have enough or excess or lack of water? How does weather affect the peanut's ecosystem in this stage?

2. Plant: How is plant height in comparison with last week? How many leaves are there on the plant? What color are they? How many branches are there? How many flowers are there on the plant? On which branches are most of them? How many elongated flower stalks are there on the plant? On which branches are they concentrated? How many tubes are there on plant? Which branches have the most number of tubes? Which branches have the biggest tubes? Is the tube size uniform throughout the whole field? Why? Are there any empty tubes? Why? How many nodules are there? Are they small or big? What color are they? What is the role of nodules? Does the plant seem to lack nutrients? How do you expect the plants to develop next week?

3. Insect pests and natural enemies: What kinds of pest insects are occurring in the fields? Are there many or just a few of them? Which is the most harmful? Are there many natural enemies in the fields? What is their ability in controlling the pest insects? How do you expect pest insect and natural enemy populations to develop in the next days?

4. Diseases: What diseases are occurring in the fields? Are there many or just a few diseases? To which disease should you give more attention? How do you expect diseases to develop in the next days?

5. Attractant/trap crop: How is the development of the attractant/trap crop? Are there any insects, eggmasses on the attractant/trap crop? Compare the number of insects and eggmasses on trap crops with those on peanuts.

6. Compensation ability: What is effect on the plant if its leaves are eaten by insects at this stage? To what extent can peanut plants compensate for defoliation at this stage? (Relate to defoliation study.) Is the plant infected by diseases? To what extent can peanut plants compensate for damage caused by diseases at this stage?

7. Management decisions: Is it necessary to apply more fertilizer? Is it necessary to water? Is it necessary to earth up, cover the roots? Why? Is it necessary to weed? What do you do to manage insects: collect insects, eggmasses ...? What do you do to manage diseases? Is it necessary to collect insects and eggmasses on attractants/trap crops? Why? What should be done to care for the attractant/trap crop? Should you continue to observe?

V. Ripening to harvesting stage
Objectives: Explain:
- characteristics of the peanut plant in ripening and harvest stage
- factors that affect this stage

Method:
- Each group should collect 20 peanut plants (10 from IPM field and 10 from CP)
- Count the total number of tubes and seeds per plant
- Take the average number of tubes and seeds per plant
- Compute for the theoretical yield of IPM and CP fields

Discussions:
1. Weather: What is the weather like today (sunshine, rain, temperature, humidity ...)? Does the soil have enough or excess or lack of water? How does weather affect the peanut's ecosystem in this stage?

2. Plant: How is plant height in comparison to last week? How many green/yellow leaves are there on the plant? How many branches are there on the plant? Does the plant continue flowering? Why? How many tubes are there on the plant? How many full sized tubes are there? Which branches have the most number of tubes? Which branches have the most full-sized tubes? Is the tube size uniform throughout the whole field? Why? What can you do to avoid this? How many nodules are there? Are they small or big? What colour are they? What is the role of nodules? How do you expect plants to develop next week?

3. Insect pests and natural enemies: What kinds of the pest insects are occurring in the fields? Are there many or just a few of them? Which is the most harmful? Are there many natural enemies in the fields? What is their ability to control the pest insects? How do you expect populations of pest insects and natural enemies to develop in the next days?

4. Diseases: What diseases are occurring in the fields? Are there many or just a few diseases? To which disease should you pay more attention? How do you expect diseases to develop in the next days?

5. Attractant/trap crop: How is the development of attractants/trap crops? Are there any insects, eggmasses on the attractant/trap crop? Compare the number of insects/eggmasses on trap crops to those on peanut plants?

6. Compensation ability: What is effect on the plant if its leaves are eaten by insects at this stage? To what extent can peanut plants compensate for defoliation at this stage? (Relate to defoliation study.) Is the plant infected by diseases? To what extent can peanut plants compensate for damage caused by diseases at this stage?

7. Management decisions: Is it necessary to apply more fertilizer? Is it necessary to water? Is it necessary to earth up, cover the roots? Why? Is it necessary to weed? What do you do to manage insects: collect insects, eggmasses ...? What do you do to manage diseases? Is it necessary to collect insects and eggmasses on the attractants? Why? What should be done to care for the attractants? Should you continue to observe?
Crop Development
Introduction

Rice is a kind of grass. Grass is a one-leaf plant because only one leaf germinates from the seed when the plant initially grows. Beans are two-germinal leaf plants because two leaves germinate from seeds when the plant initially grows. There are several ways of differentiating two-germinal leaf and one-germinal leaf plants. Two-germinal leaf plants develop from the growing point or sprout at the top of the plant. The one-germinal leaf plant develops from bottom part of plant. Two-germinal leaf plants have branches. One-germinal leaf plants have tillers. We can remove some tillers of the rice plant and the plant can compensate by producing new tillers. When the peanut plant is damaged, it can compensate by producing new leaves or new sprouts but it will die if we cut it from the base.

Plant development depends on sunlight, nutrients, water and temperature. Plant parts which are responsible for production are the roots, leaves and stems in both rice and peanuts. These organs (roots, leaves and stems) continue to develop until the plant reaches reproductive stage (panicle initiation stage in rice; emergence of buds in peanuts). At reproductive stage all plant energy is used to form new organs (panicles, flowers, fruits, seeds). No new roots, leaves and stems are formed in this stage. This is the reason that the plant can compensate for damage to parts such as roots, stems, and leaves before reproductive stage. At panicle initiation and/or bud formation this process may be difficult.

Plants may be able to compensate for damage to flowers and fruits (flower sets and seeds) at the beginning of their development stage. Lost flowers are compensated for by new flowers or by many flowers from which fruits can set. Later or towards the end of season it will be very difficult for plant to compensate if fruits are damaged.

Short duration and long duration varieties go through a similar process of development until flowering stage. At flowering stage, short duration plants produce fruits and then die. The long duration plants produce flowers and fruits more than once.

Objectives: Discuss:
- structure, morphology and function of each part of the peanut plant at stage of germination to two leaf stage
- correlation between structure, morphology, function, cultivation and insects
- similarities and differences between peanut and rice plant (representative of one germ leaf plant) at germination stage

Materials:
Peanut seeds, rice seeds
Plastic tray with soil for growing seeds
Pencil and paper

Method:
* A week before the session, plant rice and peanut seeds in wet soil on plastic tray.
* Pull up seedlings and young peanut plants after 5-10 DAS.
* Observe plant development: plant height, number of leaves, roots, nodes, etc
* Make drawings
* Continue to observe plant development for two weeks. Draw plants every week. Record all data of plant development.

Discussions:
1. What are the similarities and differences between rice and peanut plants?

2. Why is it easier to grow rice than peanuts? At this stage, what are the requirements of the two plants in terms of nutrition, water and temperature?

3. Where are the growing points of each kind of plant? Compare compensation ability of the two plants at this stage. How do the plants compensate?
I. Germination to three-true-leaves stage

The main nutrient resource for plant development after germination is the seed. When the crown root develops then the plant takes nutrients directly from the soil. These nutrients undergo photosynthesis and are transformed into organic substances which are distributed to all parts of plant.

Temperature and humidity play an important role in this stage. Under suitable temperature, seeds germinate fast. Under low temperature, seeds germinate slowly and this stage will take a longer time.

Aphids often occur and cause damage when the plant has 2-3 true leaves. Sometimes they cause significant reduction of plant density in the field.

Understanding the development of the plant at this stage provides a sound basis for appropriate management decisions.

Objectives:
Draw plant parts (germinal leaves, true leaves, roots, stem ...)
Explain factors that affect plant development
Implement management decisions based on knowledge of plant development

Materials: (for each group)
Big sized paper
Crayons
Pencils
Small knife
Germinated peanut seeds, peanut plants at 2-3 true-leaf-stage
Ruler
Plastic bags

Method:
* Prepare germinated peanut seeds and other materials.
* Collect peanut plants at 2-3 true leaves stage.
* Observe carefully peanut seeds and plants.
* Observe plant development: plant height, number of leaves, roots, nodes, etc
* Draw all parts of plant on big-sized paper (seed, germinal leaf, stem, compound leaf, roots, sucking hairs) and label them.

Discussions:
1. How many germinal leaves are there on the plant?
2. Do roots emerge first or germinal leaves?
3. From which part of the seed do roots and germinal leaves emerge?
4. What is the difference between germinal leaves and true leaves?
5. From where does the plant take nutrients after germination?
6. What factors (temperature, humidity, light, nutrients, soil, water ...) affect plant development?
7. What kinds of insects and diseases often occur in the field in this stage? Which is the most harmful? How do they damage crops? What are the management methods?
8. To what extent can plants compensate in this stage? Compare compensation of peanuts with that of rice?

II. Branch formation stage
In this stage peanuts take nutrients absolutely from the soil. The number of branches influences the number of flowers to a great extent. Most tubes are formed on the first level branches.

Some kinds of insects and diseases which occur in this stage sometimes lowers plant density. Normally, however, plants can compensate for damage caused by caterpillars.

The nutrient and water requirements of plants in this stage are not high, but enough nitrogen should be supplied for the development of stems and leaves and to increase the number of branches.

Objectives:
Discuss functions of plant organs (germinal leaves, true leaves, roots, stem, nodules ...)
Explain factors which affect plant development at this stage
Implement management decisions based on above knowledge

Materials: (for 1 group)
Big sized-paper
Crayons
Pencils
Small knife
Peanut plant at branches formation stage
Ruler
Plastic bags

Method:
* Collect plants at branch formation stage.
* Observe and describe morphological characteristics, draw all parts of plant (including distribution of branches) on big sized paper and label them.
* Measure, count and describe growth criteria (height of plants, length of roots, number of nodules, number of leaves, number of branches, buds, flowers, etc).

Discussions:
1. How many leaves are there on the plant? (Compare to previous stage.)
2. How many branches are there on the plant? What is the position of the 1st level of branches; 2nd level of branches? Compare this with development of tillers in rice.
3. Compare the compensation ability of peanuts to that of rice.
4. What factors (temperature, humidity, light, nutrient, soil, water ...) affect plant development?
5. Why should we create good conditions for plants to form branches early? How does light affect plant development?
6. What is the role of nodules? What cultivation practices do you need to create good conditions for the development of nodules?
7. What kinds of insects and diseases occur in the field in this stage? Which ones are the most harmful? How do they damage crops? What management methods are usually done for these insects and diseases?

III. Flowering - flower stalk elongation stage
One of the differences between rice and peanuts is that in rice the reproductive stage follows the vegetative stage. In peanuts, both stages take place at the same time. At 25-45 days after seeding (depending on variety and ecological conditions) the peanut plant begins to flower.

Nodules play an important role in fixing nitrogen. Loose soil is favorable for the development of nodules. During this stage, the peanut plant needs water most. The population of caterpillars can increase seriously at this stage. However, the plant ability to compensate is also high. In some cases, wilt disease causes some plants to die.

**Objectives:**
Discuss functions of plant organs (germinal leaves, true leaves, roots, stems, nodules, flowers, flower stalk ...)
Explain factors which affect plant development at this stage
Implement management decisions based on above knowledge

**Materials: (for 1 group)**
Big-sized paper
Crayons
Pencils
Small knife
Peanut plant at stages of flowering and elongation of flower stalk
Ruler
Plastic bags

**Methods:**
* Collect plants at stages of flowering and elongation of flower stalk.
* Observe and describe morphological characteristics, draw all parts of plant (including position of 1st and 2nd level branches) on big sized paper and label them.
* Measure, count and describe growth criteria (height of plants, length of roots, number of nodules, number of leaves, number of branches, buds, flowers, elongated flower stalks, etc).
* Draw flower structure.

**Discussions:**
1. How many leaves are there on the plant? (Compare to previous stage.)
2. How many branches are there on the plant? What is the position of the 1st level of branches, 2nd level of branches? Compare this with tillers in rice.
3. Which of the branches have the most number of flowers, elongated flower stalks? On which branches do flower stalks elongate first? How long does the period of elongation of flower stalks last? What cultivation practices should be done to create conditions for flower stalks to elongate well?
4. How many days after planting does the peanut plant begin to flower? How long does the flowering period last? Do flowers bloom at the same time? Why? What cultivation practices should be done to create conditions for flowers to bloom at the same time?
5. What is the significance of flower phases on yield?
6. What is the role and importance of water in this stage?
7. Compare compensation ability of peanut at this stage with that of rice?
8. How does light affect plant development?
9. What is the role of nodules? What cultivation practices should be done to create favourable conditions for the development of nodules?
10. What kinds of insects and diseases often occur in the field in this stage? Which ones are the most harmful? How do they damage crops? What are the management methods for these insects and diseases?
IV. Pod formation and development stage

At this stage, nutrients are concentrated for developing pods. Stem and leaves develop slowly. Excess application of nitrogen will intensify development of stems and leaves which will result in slowing down of pod development and decreased ability to reach its full size. Excess of water can result in pod rot affecting yield and seed quality. At this stage, damage caused by caterpillars is low, but disease may sometimes cause damage to yields.

Objectives:
Discuss functions of plant organs (germinal leaves, true leaves, roots, stems, nodules, flowers, flower stalks, pod, seed ...)
Explain factors which affect plant development at this stage
Implement management decisions based on above knowledge

Materials: (for 1 group)
Big sized-paper
Crayons
Pencils
Small knife
Peanut plant at pod formation and development stages
Ruler
Plastic bags

Methods:
* Collect plants at stages of pod formation and development.
* Observe and describe morphological characteristics, draw all parts of plant (including position of 1st and 2nd level branches) on big sized paper and label them.
* Measure, count and describe growth criteria (height of plants, length of roots, number of nodules, number of leaves, number of branches, buds, flowers, elongated flower stalks, number of small, medium and big pods etc).
* Draw pod structure at 3 sizes: small, medium, big.

Discussions:
1. How many leaves are there on the plant? Compare this with the previous stage?
2. How many branches are there on the plant? Compare this with the previous stage?
3. How many pods are there on the plant? How many big/medium/small pods are there?
4. Which pairs of branches have the most number of pods? Which pairs of branches have the biggest pods?
5. Does plant continue to flower? Do flower stalks continue to elongate? On which branches?
6. How many days after planting are pods formed? How long is the period for pod formation and development? Are pods uniform in size? Why? What cultivation practices favor good formation and development of pods at the same time?
7. What is the significance of pod formation phases on yield?
8. What is the role and importance of water in this stage?
9. Compare compensation of peanut in this stage with that of rice at booting stage?
10. What kinds of insects and diseases often occur in the field in this stage? Which ones are the most harmful? How do they damage crops? What management methods are used for these insects and diseases?

V. Ripening - Harvesting stage
At this stage, stems and leaves stop to develop. All nutrients are used to make seeds reach their full size. Excess of water at this time can make pods rot, affecting yield and seed quality.

**Objectives:**
Describe plants at ripening stage and harvest stage
Explain factors which affect plant development at this stage
Implement management decisions based on above knowledge

**Materials:** (for 1 group)
Big-sized paper
Crayons
Pencils
Small knife
Peanut plants at ripening stage
Ruler
Plastic bags

**Methods:**
* Collect plants at ripening and harvest stages.
* Observe and describe morphological characteristics, draw all parts of plant (including color of leaves, stems, color of pod/seed cover comparing the different varieties) on big-sized paper and label them.
* Measure, count and describe growth criteria (total number of pods, number of small, medium and big pods, number of old/young pods, number of pods on each level of branches etc).

**Discussions:**
1. How many pods are there on the plant?
2. How many old/young pods are there? Why are there old and young pods at the same time on one branch?
3. Which level of branches have the most old pods?
4. Compare the number of pods/plant, seeds/pod, seed size and seed color between varieties.
5. How many days after planting can you harvest?
6. What factors determine the time of harvest?
7. What kinds of insects and diseases often occur in the field in this stage?
8. What techniques can be used for better storage of peanuts after harvest?
Insect Zoo

field guide exercises for ipm in peanuts.
Some basic exercises to learn about the insects

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

Materials:
Small plastic vials
Tissue paper
Fresh prey

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

Materials:
Small plastic vials
Tissue paper
Fresh prey or plant material

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

Materials:
Insect collection box
Pins
Naphthaline balls
Life cycle of White grub and Cricket
(The same set up may be used to observe damage by these insects.)

Objectives:
Carry out a study to observe the development of soil insects such as white grubs and crickets.

Materials:
Collecting kit consisting of clear plastic bottles or bags
Cages (with organdie material) and potted peanut plants
One pencil and paper for labels
One note book
One roll of tissue paper

Methods:
During field work, when wilted or plants exhibiting damage are observed, dig out the soil around the
plant and search for soil insects. Collect these and introduce into healthy potted peanut plants. Observe
the changes in the life cycle of the insect.

Discussions:
Egg stage:
Where are the eggs laid?
How many eggs are laid in a batch?
How many days before the youngest nymphs emerged?
What is the colour of the eggs?

Nymphal stage:
Do the young insects that hatch from the eggs resemble adults?
Do you think there are differences in development of insects?
What colour is the newly emerged insect?
What colour is an older insect?
How can you tell that the insect has developed into an adult?
How long does the nymph remain in the immature stage?
Why does the immature insect change skin as it grows?
Studying parasitoids of Spodoptera

Objectives:
- Explain how parasitoids search, attack and lay eggs in the host caterpillar
- Carry out studies to confirm activities of parasitoids in the fields
- Experience methods of effectively conserving parasitoids

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

Method 1: Parasitism and stage of host
Using caged potted plants, release some adult moths and keep for 24 hours. Remove the moths when eggs are found. Do the same for other pots so that we have 7 pots with 7 different days of exposure. This will supply caterpillars of different ages. Collect parasitoid cocoons from the field (e.g., Cotesia) and keep them in small plastic containers until parasitoids emerge. Feed with honey solution (50% honey and 50% water). There should be about 20 parasitoids living together in a cage for 24 hours. This will ensure mating and help the parasitoids to be ready to attack the caterpillars. Prepare a potted plant and collect caterpillars using hair brush - two caterpillars each from a pot 6 days after egg laying, 8 days after egg laying, 10 days after egg laying, 12 days after egg laying and 14 days after egg laying. If studying Spodoptera, also introduce other kinds of caterpillars together with the Spodoptera caterpillars (no more than 2 of each type of caterpillar and preferably the younger stage). Using an aspirator (or using a small clear plastic tube) collect 5 parasitoids from the parasitoid cage and transfer to the potted plant with caterpillars of different ages. Drop some honey solution on the leaves to feed the parasitoids. Keep the parasitoids with the caterpillars for 24 hours and watch what happens. After 24 hours, remove the parasitoids and rear the caterpillars to pupal stage. Each group should have a set of experiment.

Discussions:
1. What happens when the parasitoids are introduced into the cages with caterpillars?
2. How long does it take before they find the caterpillars?
3. Which stage of caterpillars do they prefer?
4. How long does it take to lay an egg in each caterpillar?
5. During rearing, are all caterpillars parasitised? (recognized by a dead caterpillar with a hole on its side - for Cotesia)
6. If not, which stage is preferred? Why?
7. Are other kinds of caterpillars attacked? Why?
8. How many days take place/lapse between the attack by parasitoid and formation of parasitoid cocoon?
9. How many parasitoids emerge from one caterpillar?

Method 2: Emergence of parasitoid from cocoons and hyperparasitism

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

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

**Method 3: Food requirement of parasitoids:**
From newly emerged parasitoids, study five parasitoids without food using a clear plastic container. Record when they die and also record if these are males or females. For another five new parasitoids, provide honey solution (50% honey and 50% water) and record when these parasitoids die. A similar study can be done using water as food.

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

**Method 4: Effects of residual insecticides on parasitoids**
Collect three pieces of leaves from a peanut plant (free of insecticides). On one piece, spray methyl parathion, another methamidophos and the third water. Put one of these pieces of leaves each inside clear plastic containers and cover with mosquito net or organdie material. Two parasitoids are then introduced inside each container and observations made at 3 minutes, 5 minutes, 10 minutes and 15 minutes after exposure. Record if the parasitoids are still alive.

**Discussions:**
1. Are the parasitoids still alive in each treatment after 15 minutes?
2. If the parasitoids are not alive, why?
3. What does this study show?
Pest density and percentage parasitism

**Method:**

* In an unsprayed peanut field, conduct sampling twice a week (i.e. every 3 or 4 days).
* Select 20 plants at random and record numbers of Spodoptera larvae and pupae per plant.
* Also twice a week, collect 10 mature larvae and 10 pupae, and rear them individually inside plastic tubes until emergence of the moth or parasitoid. Provide some food for larvae and replace the food daily.
* Leaf pieces for food should be as small as possible to prevent condensation inside the tubes. Further, a small piece of tissue paper should be secured between the lid and the tube to avoid condensation.
* Evaluate seasonal densities of larvae and pupae, and the level of parasitism. Record and collect parasitoid species present.
* If possible, repeat the survey in other locations.
Measuring the parasitism level of caterpillars in peanuts
(This exercise can be done several times during the season.)

From time to time, we collect leaf feeders in order to observe parasites, larvae, pupa and adult that come from the host caterpillars. Certain larval growth stages act as host for some parasites. Some parasites attack the young larvae and emerge when they are strong enough. Other parasites (like Tachinid flies) attack the larva when it is strong enough and emerge during the pupal stage of the host. In this study we will observe different parasites and their hosts and relate this to their role in the field. The best way to learn about this is to observe what emerges from larvae collected from the field.

Objectives:
• Observe parasitoids of caterpillars (cutworms and greenworms)
• Explain the importance of parasitism
• Explain aspects of the biology of parasitoid species, e.g., are they restricted to certain larval growth stages on the host

Materials: (per group)
30 plastic tubes (60 ml) with labels
Tissue paper
Fresh plant material for larval feeding
From an unsprayed field: Two species of larva that are common for example, cutworm or greenworm:
- two small - (<0.8 cm),
- two medium - (0.8 - 1.5 cm)
- two large - (>1.5 cm)

If plenty of tubes are available, each group could collect more larvae.

Method: This exercise can be done any time when caterpillars are common in the field.
1. Collect larvae when peanuts have been grown for one month or when insect population starts increasing. Collections could be repeated weekly or every 14 days to study how parasitism levels change during the season.
2. Put larvae individually inside plastic tubes and label the tubes with the date of collection, host species, and size of the host at collection. Add some fresh leaves as food and secure a piece of tissue paper between the lid and tube to prevent condensation.
3. Observe each tube daily and replace food. For small caterpillars, food can be replaced once every two days.
4. Observe carefully whether parasites emerge from the caterpillar, whether the caterpillar has pupated, or whether the adult has emerged. If parasites emerge, count them and keep them for identification.
5. Continue these observations until the end of the course, until parasites or adult moths have emerged, or until the host has died to other causes. Calculate the intensity of parasitism for each stage (small, medium, large) of the host as follows:

\[
\text{% parasitism} = \left( \frac{\text{parasitized larvae}}{\text{total larvae}} \right) \times 100\%
\]

6. Make calculations for every sampling occasion and evaluate how parasitism fluctuated during the season.

Discussions:
1. What were the parasitism levels of each pest species?
2. Compare different parasitism levels between the three kinds of host (small, medium, large) caterpillars. Which stage has the highest parasitism level? Did you find different parasite species in the small, medium and large stages of the host? Could you explain why?

3. What were the different kinds of parasites in the different stages of the host larvae? Why? Describe the parasite species found in each pest; which parasites occurred in both pest species? Which occurred in only one pest species?

4. Describe how each parasite species developed in the tubes (e.g. was development mostly inside or outside the host; how many parasites emerged per host; from which host stage did the parasite emerge). Relate parasitism level and insect population in the field.
Field parasitism of eggs of cutworm and greenworm

Introduction:
Cutworm and greenworm are insects that may cause some degree of damage to peanut plants. Even in a balanced ecological system, their population can sometimes reach high levels. However, there are many natural enemies - both parasites and predator - which are able to keep the population of these insects in check.

Objectives:
- Observe if eggs of cutworms and greenworms are killed by parasitoids
- Identify kinds of parasitoids that attack eggs of cutworms and greenworms
- Estimate the level of parasitism caused by the egg parasitoids
- Observe seasonal fluctuations of host eggs and level of parasitism
- Compare level of parasitism between sprayed and no spray fields

Materials:
- Sprayed and unsprayed cotton fields
- Plastic bags/bottles
- Scissors
- Fine hair brush
- Fine pointed forceps
- Tissue paper
- Labels
- Eggmasses of greenworms and cutworms
- Rubber bands

Method:
1. The exercise can begin soon after peanut plants are established in the field.

2. Weekly collect leaves with greenworm and cutworm eggmasses. To collect eggs, use a pair of scissors and remove the plant tissue around the eggs and using the forceps place the plant tissue and egg(s) into clean plastic bags/bottles. The bags/bottles should be lined with a moist tissue paper (not wet or the eggs will drown). Close the plastic bags with rubber bands. Cover plastic bottles with cloth and secure with rubber bands. For each field visit the bags/bottles used should be labelled with field number, date and name of collector.

3. Keep the bags/bottles in a cool place away from direct sunlight. Observe everyday for two weeks in order watch for emergence of larvae and/or parasite wasp. Count and record the number of larvae, parasite wasp and eggmasses which do not hatch in each eggmass.

(Note: Parasite wasps often emerge some days after the emergence of larvae. Continue observing within two weeks after the larvae have emerged. Use emerged larvae to check predator ability of spider, lady beetle and carabid beetle. . .)

4. Calculate the level of parasitism using the following formula:

% parasitism = (number of eggs parasitized/total number eggs collected) X 100%

5. Calculations should be made for every sampling occasion and data for the whole season can be plotted using both number of eggs and % parasitism on the Y-axis and date on the X-axis.

6. After processing the data and preparing the graphs, discuss the results with farmers, extension workers and researchers. The points of discussion should follow the sequence given in the objectives above.

Discussions:
1. What is the percentage of parasitism? Is the level of parasitism consistent throughout the season? If the level is consistent, why? If the level is not consistent, why not?
2. What is the percentage of eggs which did not hatch? What factors affecting hatchability of eggs?
3. What is effect of pesticides on parasites?
4. Are there any differences in level of parasitism between sprayed and unsprayed fields? Why is there a difference?
5. What have we learned from this exercise?
6. Is there any way we can improve this study?
Direct observations of consumption rates of predators in the field
(This exercise can be repeated several times during the season.)

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

Objective:
Observe consumption rates of predators in the field
Observe the role of predators in the control of thrips
Explain why direct observation is an important part in predator study

Materials:
Hand lens, watch, whistle

Method: The timing of this exercise is important because the data on population of natural enemies and insect pests can be related to what is going on in the bigger field.

1. Early morning at 8 am, the trainees are briefed, and are divided into 3 groups that will each observe a particular predator species in an unsprayed field:
   - Short-winged carabid beetle
   - Last stage of larvae of lady beetle
   - Adult lady beetle
2. Other predators may be chosen depending on their availability in the field but this exercise is not suitable for easily disturbed predators, such as spiders.
3. Each member of the group is required to find a predator of the appropriate species. When everyone has found a predator, a field leader gives a whistle to start the 10 minute observation and everyone follows his predator and counts the number and sizes of the prey it eats within a ten minute interval. The predators should not be disturbed and should not be given prey because we want to observe the natural feeding behaviour.
4. After 10 minutes, the field leader gives a second whistle to end the observation. Everyone gathers and the results of everyone's observations are compiled on a board directly in the field. The average predation rates (per hour) are calculated for each predator.
5. The same activity is repeated at 1100 am and (if possible) at 1700 pm, in order to compare the activity of predators at different times of the day. For each time of observation, each group should choose a different kind of predator for different study or observation. For example,
   - 11am: Group 1 - Adult lady beetle
     Group 2 - Short-winged carabid
     Group 3 - Last stage of larvae of lady beetle
   - 5pm: Group 1 - Last stage of larvae of lady beetle
     Group 2 - Adult lady beetle
     Group 3 - Short-winged carabid
6. After each observation, results are compiled and discussed in the "field class". Relate observations to population of thrips in the field.

Discussions:
1. Are there differences in feeding rates at different times of the day? Why? How many prey can each predator feed on per hour? Based on this, how many days will it take for each predator to eat all thrips?
2. What is the preferred prey of each predator species?
3. Describe the feeding habits of the three predators.
4. Which predator is most efficient for low population of thrips? Why? For high thrip populations? Why? Which predator is the most active searcher?
5. Can we also make direct observations on Lycosa? Why? Why not? When the pests are less common, would the predators eat the same numbers of prey or less? Why?
6. After several observations, relate predator consumption rates and thrip population.
Predation on insects in the laboratory

A number of predators may feed on sucking an chewing insects in the field. To evaluate their consumption rate we conduct a simple study in the laboratory. This study could be conducted on thrips or Spodoptera larvae.

**Objective:**
- Observe consumption rates of predators in the laboratory
- Compare predation ability of natural enemies on thrips and larvae

**Materials:**
- 20 clear plastic or glass tubes (60 ml)
- Some tissue paper
- Scissors
- Fine brush
- Hand-lens
- Tube labels

**Method:** (per group)
1. Collect 10 predators
   - Carabid beetles (short winged)  2
   - Larvae of lady beetle   2
   - Adult lady beetles   2
   - Lycosa (large size)   2
   - Long-horned cricket   2
2. Put predators individually inside plastic tubes and do not feed them for 6 hrs. Always keep the predators away from direct sunlight.
3. At 2pm collect peanut plants with high thrip population, i.e., about 250 wingless thrips. Also collect 40 young Spodoptera larvae, i.e., 2nd instar and 10 young peanut leaves.
4. Put leaves individually inside big plastic tubes and number them from 1 to 10. Put 40 big-sized thrips inside each tube from nos. 1-5. In each of tubes nos. 6 -10 put 8 small Spodoptera larvae.
5. Secure a piece of tissue paper between the lid and tube to prevent condensation. One part of the tissue must be inside tube and the other end outside.
6. Introduce the predators. Check on predation after some time but do not touch them.
7. After 24 hours carefully count and record the number of remaining pests (that are alive) inside the tube or on the leaf fragment of each tube. Check whether you can retrieve any remains of pests that have been killed. Also note the condition of the predators.

<table>
<thead>
<tr>
<th># of tube</th>
<th>Predator</th>
<th>Prey</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Carabid beetle (short wing)</td>
<td>40 thrips</td>
</tr>
<tr>
<td>2</td>
<td>Young lady beetle</td>
<td>40 thrips</td>
</tr>
<tr>
<td>3</td>
<td>Adult lady beetle</td>
<td>40 thrips</td>
</tr>
<tr>
<td>4</td>
<td>Lycosa</td>
<td>40 thrips</td>
</tr>
<tr>
<td>5</td>
<td>Cricket</td>
<td>40 thrips</td>
</tr>
<tr>
<td>6</td>
<td>Carabid beetle (short wing)</td>
<td>8 Spodoptera</td>
</tr>
<tr>
<td>7</td>
<td>Young lady beetle</td>
<td>8 Spodoptera</td>
</tr>
<tr>
<td>8</td>
<td>Adult lady beetle</td>
<td>8 Spodoptera</td>
</tr>
<tr>
<td>9</td>
<td>Lycosa</td>
<td>8 Spodoptera</td>
</tr>
<tr>
<td>10</td>
<td>Cricket</td>
<td>8 Spodoptera</td>
</tr>
</tbody>
</table>

8. Calculate the average number of pests that disappeared (were eaten) in each treatment (predator 1, predator 2, predator 3, predator 4 and the control).
9. Compare the results with those of other groups.
   This study must be repeated several time in season when insects occur in the field.

**Discussions:**
1. How many of each prey did each predator consume in 24 hrs? What happens if you put many preys inside the tube?
2. Which predator species ate most and which ate least?
3. What is the value of having a control without a predator?
4. Why do we use wingless thrips? Why do we use the young larvae?
5. Do predators behave differently in tubes than when free-living in the field? Where would the predators feed more: in tubes in the laboratory or in the field? Explain why.
Predation on sucking insects in exclusion cages

**Objectives:**
Observe role of predators in reducing thrip populations in the field
Compare predation in open and closed cages

**Materials:**
20 nylon field cages (40cm x 40cm x 90cm) with 8 pieces of bamboo (90cm in length) for support
Labels to number the cages
Small tubes to catch natural enemies
Unsprayed field with plenty of sucking insects (thrips)

**Method:**
1. Each group select individual plants for caging. Choose two groups of peanut plants similar in the size and number of thrips.
2. Construct a cage around each selected plant by putting bamboo sticks around and covering them with plastic bags.
3. Remove all natural enemies (even the ants) from the cages. Leave only the thrips. Bury the edges of the plastic bags in the soil so that natural enemies cannot come in.
4. Toss coins to determine which of the cages will be closed and which ones will be open.
5. Introduce the last stage of lady beetle larvae in one cage using the number agreed upon. This number will depend on its population in the field at this time.
6. After five days, lift the bottom margin of the cages and carefully count the thrips in each cage. Record the number of young thrips or adult thrips. Record the number of natural enemies in each size and kind in each cage. Check all plant parts systematically from the bottom of the plant to the top.
7. Calculate the average number of whiteflies, jassids and aphids in closed cages (without predators) and in open cages (with predators).
8. Obtain the data from other groups and calculate the average number in cages with and without predators. Discuss in class.

**Discussions:**
1. Why is it necessary to check for results after five days and not two weeks? What would happen if we left the cage unobserved for two weeks?
2. Can you use this exclusion cage method for studies on other natural enemies?
3. Does this study allow you to see the direct effect of predation on thrips?
4. Are there other natural enemies outside the cage which can eat thrips?
5. Besides predation, what other factors influence the population of sucking pests?
Pesticides
Demonstration of Pesticide Poisoning

Introduction:
Sometimes seeing is believing. This is a terrible activity for demonstrating the effects of toxic compounds on animals. This activity should be done with discussion on other persons experiences with poisoning.
There are antidotes available for some cases of pesticide poisoning. Read pesticide labels and ask at the local health center if these are available.

Objective:
Demonstrate pesticide poisoning

Time required:
120 minutes

Materials:
Wire cages or buckets, small paper dishes, chicken feed, chickens (and/or fish, frogs, etc.), pesticides (like methylparathion, monocrotophos, carbofuran), spoon, pencil and paper.

Method:
1. Place chicken in cages (or fish in buckets with water). Frogs can also be used if forced to feed. Do not feed the animals for several hours before the activity.
2. Mix pesticide with chicken feed (or directly in water if using fish).
3. Feed the food to young chickens. Let some chickens feed a lot and other chickens a little. Change dosage for each group.
4. Observe the behaviour of the chickens for 45 minutes. Note the symptoms of poisoning and the time at which each symptom begins.
5. What are the reactions of the chicken to the feed? Have you ever seen similar symptoms of friends or other farmers after spraying? Have you ever seen a pesticide suicide case? What happened? Do you think that antidotes will work? How different is the physiology of chickens and people? With long-term exposure to pesticides, what do you think is the result to the rural population?
6. Present your results to the other groups.
Spraying

Introduction:
Spraying pesticides is dangerous. The compounds used for spraying are in a concentrated form which makes them even more dangerous than usual exposure. Concentrated liquids direct from the bottle, and exposure to sprays in the field during application will cause numerous symptoms such as skin rashes, dizziness, nausea, and headaches.
The usual recommendation for gloves, boots, rain clothes, and respirator are impossible to implement for most farmers because of the costs.
The direction and velocity of the wind should be considered when spraying. If the wind is blowing hard, do not spray! Your chemical will never reach most of the plant. Never walk into the wind when spraying. Always walk at a 90 angle to the wind.
In this activity you will see the result of spraying in the field.

Objective:
Demonstrate simple adaptations to reduce exposure to poisons

Time required:
120 minutes

Materials:
Sprayer, bucket, red dye, white pants and shirt

Method (for group of five):
1. Go to the field. One person in the group should put on the white pants and shirt. Four other members should make notes on what the first person is doing. Note especially how to reduce exposure to the spray liquid.
2. Fill the tank with water. Add red dye. Add a lot so that the water is very red. Close the tank and shake the tank to mix the water and the dye.
3. Now spray 500 m2 of the field with the tank of water and dye. Others should measure the time required and observe the spraying.
4. After finishing spraying, empty the excess spray.
5. Now observe the sprayer. Is the red dye on the skin or clothing of the person who sprayed? What could be done to reduce the exposure? What would happen to the person if the liquid was a real pesticide and the farmer used his regular spraying clothes?
6. What symptoms can be caused by pesticides? What are the experiences of the groups with spraying pesticides?
7. Present your observations, discussion and clothing to the other groups. Discuss "Is there really 'safe application' of pesticides?".
Effects of pesticides on natural enemies

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

Materials:
4 jars with lids
4 pieces of Muslin cloth with rubber bands, to close jars (Method 2)
Labels
Paper and pen
Four small handsprayers (0.5 ltr)
Small amounts of insecticides

Method 1:
1. Prepare 4 hand sprayers before the practical. If a sprayer has been used before, wash it thoroughly with detergent. Prepare and fill 3 handsprayers with commonly used insecticides, at field rate concentrations, for example: monocrotophos (organophosphate), cypermethrin (pyrethroid), Bt (biological insecticide). Fill one handspayer with water (control).
2. Select 4 plants in the field: one plant per spray treatment. Label each plant with the name of the treatment. Spray the labeled plants with the corresponding solution and let the leaves dry on the plant.
3. Pick one or several leaves from each treatment and transfer to glass jars (use gloves). Label the jars. Each group should have one jar of each spray treatment (4 jars in total). Try to get the leaf to lie flat on the inside surface of the jar.
4. Collect several predators from the field. Transfer them to the jars. Use the same predator species in all treatments. Close the jar with the lid, and place a piece of tissue paper between the jar and the lid to avoid condensation inside the jar.
5. Check and record the condition of the predators after 8 hours and after 24 hours. Count the number of dead insects. It may be necessary to touch the insect with a pen or pencil to determine if it is dead. If it does not walk off in a normal manner, then record it as dead.

Method 2:
1. Prepare 4 hand sprayers as in Method 1.
2. Spray each piece of muslin cloth with a sprayer and let the cloth dry. Label the cloth (use gloves!).
3. Collect several predators from the field and transfer them to 4 jars per group. Use the same predator species for all treatments. Close the jar with the sprayed muslin cloth.
4. Check and record the condition of the predators after 8 hours and 24 hours. Count the number of dead insects. It may be necessary to touch the insect with a pen or pencil to determine if it is dead. If it does not walk off in a normal manner, then record it as dead.
Bacillus Thuringiensis
Assessment of viability of Bt

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

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

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

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

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

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

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

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

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

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

Discussion:
1. Were there any differences in feeding between Bt treated and water treated leaves?
2. When did these difference occur?
3. Were there any differences in amount of faecal matter produced?
4. What do these differences indicate?
5. Why did the larvae stop feeding?
Sensitivity of Bt to sunlight

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

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

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

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

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

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

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

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

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

Introduction
This exercise shows that without knowing names of diseases, one can group types of diseases and learn about the developmental stages of a disease in the field.

Objectives:
• Distinguish between different groups of disease symptoms
• Compare developmental stages of each disease group

Materials:
Peanut field with different diseases in different progressive stages
Hand lens (at least one per group)
Drawing paper and crayons

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

Observations:
In the classroom, group the disease symptoms based on symptom groups like leaf spot diseases (including molds/mottling), stem disorders, wilts, pod rots, and root disorders. Assign each disease group to a group of trainees. Ask each group to rank the symptoms in order of severity. Use the hand lens to check for spores of fungi. (Spores can sometimes be seen as moldy dusty appearance on a diseased area.)

Ask groups to draw the details of the different symptoms and disease development in color. Avoid the use of scientific terms such as Latin names of diseases.

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

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

Objective:
List down available information on disease ecology and management of diseases

Materials:
Drawing paper and markers

Method:
List down diseases of the crop using the following guide questions. Remind trainees that “I don’t know.” is a truly valid answer and a better answer than “I guess . . .” at all times.
- Which diseases of this crop do you know? (Use local names.)
- What are the symptoms of the disease/s?
- When does it occur?

When the list is completed, classify them according to disease group using the question:
- Is the disease caused by a fungus, bacterium, virus or nematode?

After completing the task of grouping the diseases according to disease groups, focus on the method of spread. Ask participants to recall their observations of diseases in the field and how they spread. Use the following questions:
- Does the disease spread through water?
- Does the disease spread through infected seeds?
- Can it survive and multiply on weeds?
- Can it survive on plant residues?
- Can insects spread the disease?
- Can humans spread the disease?

If they are not certain, follow up each question with:
- What experiments can be designed and conducted to find out about this?

List information about disease groups on poster paper and put them up on the walls. These posters may be used as reference during future sessions.
**Disease groups game**  
*This is an activity which may be used as an icebreaker to start a session on disease groups.*  

**Objective:**  
Illustrate a simplified distinction of disease groups

**Method:**  
Demonstrate how to make movements to represent different disease groups. For example:  
- a bacterium places her hand behind the back, wiggles it like a tail, while circling in a spot  
- a fungus outstretches arms and fingers like a tree  
- a virus stands rigid and tall like a rod-structured virus particle  
- a nematode moves one arm like a snake

Everyone stands in a circle. An ‘it’ stands in the center of the circle and gives instructions. First, everyone in the group makes the gestures that signifies the disease group that is called out by the instructor. When everyone is familiar with the gestures, the game can start.

The ‘it’ points randomly at a participant and calls out a disease group, e.g., nematode. The participant must show the gesture that signifies the group mentioned, in this case, move one arm like a snake. In case the participant fails to show the correct gesture, she is eliminated from the circle. The game continues until only one player is left.

**Study of symptom development of leaf spots: session room exercise**
(This exercise is best done at the same time as the field exercise.)

**Objective:**
Observe the symptoms of leaf spot diseases

**Materials:**
Peanut field with symptoms of leaf spot diseases
Petri dishes, jars, clear plastic boxes
Tissue paper
Labels/tags
Poster paper, crayons, ruler, hand lens

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

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

**Observations:**
Draw each leaf spot and the area around the spot in detail, using crayons. Measure the diameter of the leaf spot. Use a hand lens to see whether you find any granular structures in the leaf spot (sporulation). Observe the leaf spot each or every other day and regularly draw and measure the size of the leaf spot. After one week, groups can be asked to present their findings.

**Discussions:**
1. What happens with a leaf spot over time (color, structure, area around spot)?
2. What is the difference between a fungal leaf spot and a bacterial leaf spot?
3. What is the difference between a disease spot and insect injury?
4. Is the leaf spot disease harmful to the crop?
Study of symptom development of leaf spots: field exercise

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

Objective:
Observe the symptoms of leaf spot diseases

Materials:
Peanut field with leaf spots
Labels/tags
Poster paper, crayons, ruler, hand lens

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

Observations:
Draw each leaf spot and the area around the spot in detail, using crayons. Measure the diameter of the leaf spot. Use a hand lens to see whether you find any granular structures in the leaf spot (sporulation). Observe the leaf spot each or every other day and regularly draw and measure the size of the leaf spot. After one week, groups can be asked to present their findings.

Discussion:
1. What happens with a leaf spot over time (color, structure, area around spot)?
2. How can one recognize the first beginnings of a leaf spot?
3. What is the difference between a fungal leaf spot and a bacterial leaf spot?
4. What is the difference between a disease spot and insect injury?
5. What was the effect of the weather during the experiment?
6. If the exercise was done simultaneously with the session room exercise: Was there a difference in the development of leaf spots in the field and in the session room? If yes, why?
Study of symptom development of bacterial wilt disease

Wilt disease has serious influence on peanut plants. This disease may be caused by other factors like fungus but the main agent is bacteria. In this activity we learn more about wilt caused by bacteria by doing some pot experiments.

Objectives:
• Diagnose symptoms of bacterial wilt disease on peanut plants
• Observe spread of bacterial wilt disease
• Discuss management practices for bacterial wilt disease

Materials:
Field of peanut plants with different diseases
Two transparent plastic glasses per group
Toothpicks (at least six pieces per group)
Clean water
Potted healthy plants (4 per group)
Drawing paper, crayons
Knife

Method: Part I - Extracting the Inoculant
At the beginning of the season, each group should establish seedlings in four pots.
When disease starts to be observed in the field, visit the field and collect 3-5 infected plants per group. Carefully observe the appearance of the infected plants exhibiting symptoms of wilt disease. In the session room, set up the experiment following the steps:
1. Cut off roots and leaves of the plant. Cut the stem into pieces of 10 cm each. (Note: Do not wash or clean the knife. This will be used to infect healthy plants in the second part of the experiment.) Stick three pieces of toothpicks into the stem to form a tri-pod so that the stem can be set up in the glass vertically.
2. Half fill the glass with clean water and put the stem in. About 3-5 cm of the stem should be in the water. Put the glass in a well lighted area of the room for easier observation.
3. Observe after thirty minutes. Participants should not move the experiment so that the water is not disturbed.
4. Based on results of the experiment, i.e., when participants have established that the plant is infected by bacterial wilt disease use water to establish pot wilt disease study. (Note: Plants infected by bacterial wilt disease will have ooze coming out of the stem and moving into the water as a white substance.)

Part II - Spreading Bacterial Wilt Disease
To set up pot studies on spread of wilt disease, use the following steps:
1. Each group should set up four pot studies to observe spread of bacterial wilt disease using the seedlings established in pots at the beginning of the season.
2. Infect using the following methods:
   2.1. Pot 1: Using inoculant (water) from Part I of the experiment inject ooze solution in collar of plant.
   2.2. Pot 2: Using inoculant (water) from Part I of the experiment inject ooze solution into leaves.
   2.3. Pot 3: Damage roots under the soil by a syringe. Put cotton with ooze solution to wound.
3. Keep another pot for control/comparison.
4. Observe results.

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

Discussions: Display results to whole group.
1. What were the symptoms of bacterial wilt disease in the field? How is this distinguished from symptoms caused by nutritional deficiencies or mechanical damages?
   * How do you identify the disease (what are the symptoms, where are the symptoms located)?
   * Where does the disease come from?
   * How does the disease spread?
   * How does the disease enter the plant?
2. Why did we use potted plants and not the field for the infection study?
Spread
Factors that influence disease development - exercise 1

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

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

DISEASE: Leaf disease like blight
(Use the same table for stem or root diseases such as wilt, rot, etc.)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Favorable</th>
<th>Unfavorable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weather</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microenvironment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other factors</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. For each factor and disease discuss and write down which aspects are favourable and unfavourable to disease development.

3. Present results to the whole group and discuss together. As groups present, summarize results into one table.

4. Supply additional information and correct misconceptions, if necessary.

If many diseases are important, spread the exercise over 2 weeks.
Factors that influence disease development - exercise 2

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

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

a) Weather
   i) Temperature
   ii) Humidity
   iii) Dew period
   iv) Rain
   v) Wind

b) Soil conditions
   i) Intrinsic soil properties
   ii) Fertilizer applied

c) Microenvironment - the conditions right around the plant that could be affected by -
   i) Number of leaves
   ii) Plant density
   iii) Water conditions

d) Water conditions
   i) Drought stress
   ii) Flooding

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

Materials:
Big piece of paper and pens
Paper cut into small pieces

Method:
1. List different factors that have an effect on disease, using the results of last week's exercise.
2. Organize the list into groups of related factors (classify by weather, microenvironment, etc...).
3. For each of the aspects, discuss how the factor affects disease. (See table below if ideas are needed.)
4. For each factor, set various conditions.
   a) Fertilizer
      i) high amount of fertilizer
      ii) medium amount of fertilizer
      iii) low amount of fertilizer
   b) Temperature
      i) high
      ii) medium
      iii) low
   c) Humidity
      i) dry air
      ii) wet air
   d) Rain
      i) heavy rainfall
      ii) moderate rainfall
      iii) drought
   e) Variety
i) resistant variety
ii) moderately resistant variety
iii) moderately susceptible variety
iv) susceptible variety
f) Crop stage
   i) germination to three true leaves stage
   ii) branch formation stage
   iii) flowering and flower stalk elongation stage
   iv) pod formation and development stage
   iv) ripening and harvest stage

5. For each factor, each group should make a pile of cards with different conditions written on different cards.
6. Within each small group, each person should pick a card from each pile. The combination of cards will specify the situation. Each person should describe to the group how much disease they expect to have and how they will handle the situation.

**Discussions:**

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

a) medium amount of fertilizer
b) high temperature
c) wet air
d) moderate rainfall
e) moderately resistant variety
f) flowering and flower stalk formation stage

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

**Leaf Blight**

<table>
<thead>
<tr>
<th>Factors</th>
<th>How they influence disease development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer</td>
<td></td>
</tr>
<tr>
<td>Plant density</td>
<td></td>
</tr>
<tr>
<td>Weather</td>
<td></td>
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Each group should present their tables to the big group. Discuss and summarize results.
Demonstration of spread of diseases

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

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

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

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

Also, try using two plots of dry, bare soil (each about 1 X 2 m²). Leave one plot bare and cover the other plot with mulch, e.g., rice straw, sugarcane bagasse, leaves from trees. Place sheets of poster paper along the 2 m border of each plot. Water each plot and compare the soil splash on both pieces of poster paper.

II. Demonstration of spread of disease by soil cultivation
Make sure that the soil is dry. Sprinkle 1 kg of flour on the soil between several plant rows and explain that this represents spores of a fungal disease or nematodes. In one row, ask a participant to use the hoe or other farming tool/s (wet the tool first) and simulate weeding of the field. In another row, ask the participants to wet the soles of their shoes/boots/feet and walk through the flour on their way to inspect nearby plants. Observe spread of flour. In case the field is wet, replace the flour by fine seeds and observe after germination of weeds.

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

Discussions:
1. What did you observe?
2. Which diseases do you know spread in this way, i.e., splash; soil; insect?
3. How might these methods of spreading disease affect crops in the field?
4. How could spread of disease be prevented?
Virus and Vectors

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

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

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

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

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

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

II. Simulation of virus being transmitted by vector
1. Set up three groups of four clear cups. Put water in each cup. In the first cup, put a drop of food colouring ("virus").
2. Dip the straw ("mouthparts") in the first cup just for a moment. Then dip into the next three cups. What happens in each of the cups? What kind of transmission does this simulate?
3. Now place some cotton in the end of the straw ("mouthparts"). First dip the straw in the "virus" and then into the next cups. Is there any difference in the results from this and the previous treatment?
4. Leave the mouthparts in the virus for a minute. Now dip the mouthparts in the other plants and leave them for a minute in each cup. What is the result? What kind of transmission does this simulate?

Discussions:
1. In the field, just a few insects are able to transmit virus, but often there are many virus infected plants. Why?
2. Why control virus vectors when a large number of plants are infected with the virus? Is there a reason to control the insects? What about the economic analysis of such a situation?
3. What are the important viruses transmitted by insects in peanuts?
Study of spread of fungal leaf spot

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

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

Method:
First day preparations:
Germinate spores by inserting the leaf spot infected leaves in a plastic bag with moist (not soaking wet) tissue paper. Close the bag tightly but leave some air inside to avoid rotting. Leave the bag overnight.

Second day:
Bring the potted plants into the classroom. Put clean tap water into the container of the small hand sprayer. Spray two potted plants with clean water. Label one plant 'healthy control, uncovered'. Cover the other plant with a plastic bag and label the plant 'healthy control, covered'.

Prepare the disease inoculum by grinding and squeezing out extract from leaves and adding this to water OR by stirring the leaf portions with leaf spots in a glass with clean water. Transfer the inoculum to the small hand sprayer. Spray the inoculum on the other two potted plants. (Note: Add sticky substance to the solution, e.g., Tween 80 Liquid Detergent, so that the spores will stick to the plant.) Label one plant 'leaf spot infected, uncovered'. Cover the other plant with a plastic bag so that high humidity is maintained and label that plant 'leaf spot infected, covered'. Clean the hand sprayer carefully after use. The plastic should not be removed, except for observations or watering of the plants.

On all four pots, spray water 6 - 8 times per day to create the environment for disease development.

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

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

Pot experiment to test whether root diseases are soil borne
**Objective:**
Demonstrate disease development of healthy plant material in contaminated soil

**Materials:**
Peanut seeds  
Four or more large pots  
Clean soil  
Labels

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

**Discussions:**
1. Why did we use potted plants and not a field for the infection study?  
2. How many weeks did it take before symptoms became visible?  
3. Can you estimate the yield loss in the field?  
4. How does the disease spread in a field?

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**Test of peanut seed quality**

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

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

**Materials:**
Peanut seeds
Tissue paper
Clear or black plastic bags
Clean water
Hand lens

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

For each seed lot:
Prepare two layers of tissue paper and carefully sprinkle clean water on the tissue. The tissue should be moist but not soaking wet. Position the 100 seeds on the tissue paper in 10 rows of 10 seeds with a distance between seeds of about 3 cm. The seeds will stick on the moist tissue. Cover the seeds with another layer of tissue paper and also slightly moisten the top tissue layer with clean water. Loosely roll up the tissue with the seeds inside into a ‘sausage’. Put the roll into the plastic bag to keep it moist. Close the bag but leave some air inside. Label the bag either “floating seeds” or “sinking seeds”, according to the seed lot inside. Keep the bags in a dark place.

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

**Discussions:**
1. Was there a difference in germination between the treatments?
2. Was there a difference in the number of seeds with mold growth or rot between treatments?
3. What would happen with the seeds of each lot in a seed bed?
4. Why should the use of diseased seeds be avoided?
Effects of inundation of fields on incidence of wilt diseases

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

Materials: 
Dryland soil from a field continuously planted with peanuts with a history of wilting disease
Wetland soil (of a similar soil type as the dryland soil) from a paddy rice field (preferably one that has been flooded with water for two to three months)
Peanut seeds

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

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

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

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

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

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

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

Materials:
Big paper and markers

Method:
(Brain-storming is a method of getting lots of creative ideas. Many ideas will not be useful, but the ideas will act as seeds to other ideas. Discussion of ideas is allowed only after all ideas have been written down)
1. Assign one person as the secretary who will write on the large piece of paper. Do not use a small piece because the whole group should be able to read the paper. Assign another person to be the facilitator.
2. The secretary should write "Area-Wide Disease Management" on the top of a large piece of paper.
3. The facilitator should ask the group what methods farmers practice in their localities to manage diseases.
4. The group members should tell the secretary their ideas. The secretary will write down the ideas. No comments are allowed by other members at this point. If any member makes comments, the facilitator must ask the person to be quiet.
5. Continue writing down ideas with no discussion until the first page is full.
6. After the page is full, discuss each idea beginning at the top of the list. The Facilitator should be sure each person can make some comments. The Secretary should summarize the discussion on each point. Write the summaries on another large piece of paper. The summary should be along the angles of the disease triangle, i.e., some activities are related to the management of disease by effecting some changes in the environment; some have to do with the plant and others have to do with effecting changes in the disease organism or pathogen.

7. If there is time, do the same process with the following question: "What can IPM trainers do to help manage diseases in our village?".
Disease triangle to explain disease management

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

Objectives:
• Reinforce discussions on disease management
• List down management practices for each component of the disease triangle to ‘inactivate’ disease spread

Materials:
Big paper, pens, markers

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

Draw the disease triangle:

DISEASE

CROP

ENVIRONMENT

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

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

Crop angle (Is a susceptible crop present?):
1. Search for resistant cultivars by planting a portion of the field with other landraces from neighboring areas and/or imported cultivars (Is the crop present? -> No? -> How would you apply this method in the field?).
2. Crop rotation by avoiding planting susceptible crops for several cropping seasons (Is the crop present? -> No? -> How would you apply this method in the field?).
3. Weeding of susceptible weeds (Is the crop present? -> No? -> How would you apply this method in the field?).

**Environment angle (Is a suitable environment present?):**
1. Choose a season that is not favorable for disease, e.g., the dry season (Is the environment favorable? -> No? -> How would you apply this method in the field?).
2. Change from overhead irrigation to flooding to reduce leaf wetness (Is the environment favorable? -> No? -> How would you apply this method in the field?).

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

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

Materials:
Big paper, pens, markers

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

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

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

Identification
Identification of disease symptoms
Disease groups
Disease groups game
Study of symptom development of leaf spots: session room exercise
Study of symptom development of leaf spots: field exercise
Study of symptom development of bacterial wilt disease

Spread
Factors that influence disease development - exercise 1
Factors that influence disease development - exercise 2
Demonstration of spread of diseases
Virus and vectors
Study of spread of fungal leaf spot
Pot experiment to test whether root diseases are soil borne
Test of peanut seed quality
Effects of inundation of fields on incidence of wilt diseases

Management
Disease management
Disease triangle to explain disease management
Management of different disease groups
Suggestions for Farmers’ Groups
Proposed weekly activities for farmers’ group

1. Observation of field studies
2. Data collection on and drawing of agroecosystem
3. Presentation of results of field studies and agroecosystem analysis
4. Observation of and presentation of findings from insect zoos which focus on:
   • predation
   • parasitism (larval; egg)
   • life cycle of pests and natural enemies
5. Discussions on special topics which may include:
   • plant development and management at different stages (to include water management; fertilizer management; post harvest techniques - storage; germination procedures)
   • insect pest management
   • disease management
   • effects of pesticides on pests and natural enemies
   • rodent management
Suggestions for field day

The field day for peanuts is primarily the same as that of any regular field school in terms of objectives as well as activities. The activities may include the following:

1. **General report** - including a summary of information about the field school - when the field school started, how participants were selected, the number of participants, the studies conducted, other activities like insect zoos, etc.

2. **Field visit** - farmers present their studies, explain the methodology for carrying out each one as well as allow everyone to see the results of the studies in the field

3. **Exhibits/display** in the room to include:

   3.1. **Graphs** showing results of -
      - Different management practices
      - Variety study
      - Fertilizer study
      - Mono cropping/mixed cropping
      - Defoliation study
      - Plant removal
      - Liming
      - Simulation of damage by young leaf feeders
      - Earthing up
      - Different dosage of lime
      - Planting density
      - Dosage of phosphate

   3.2. **Drawings** of life cycle of diseases

   3.3. **Insect zoos** and their results

4. **Exchange of ideas** between visitors and farmers

**Suggestions for exhibits**
Some materials which may be prepared for the exhibits/displays are described here. Data to be presented is gathered over the season and work on graphs are spread over several days to allow for sufficient time for preparation. FOR EACH STUDY, the following materials may be considered for presentation:

1. Plant development - Separate bar graphs on:
   - plant height
   - number of leaves
   - number of branches
   - number of flowers
   - number of full tubes
2. **Summary tables** on weekly observations for each study including general ideas and recommendations. This might also be in the form of graphs for some major pests and natural enemies so that it is more clear to the viewers.

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General ideas:

Recommendations:
3. **Bar graphs** on:

- yields
- production costs and economics
- pesticides

![Bar graph](image)

3. **Graphs** of disease development for each treatment. (The legend should be indicated on the paper.)
Planning and evaluation session

Towards the end of the season it will be helpful to conduct an evaluation and planning session for two reasons. First, this is the first time that field schools have spent a full season on the subject of peanuts and the farmers’ inputs on how to improve the studies and the exercises are important. Second, the session will allow farmers to develop plans for further activities on peanuts.

For the session, the following questions may be discussed with the farmers:

I. About the activities in general
1. What concepts were new or old?
2. What aspects were valuable? Which were not worthwhile?
3. Are there ideas that could be better introduced or explained in another way?

II. Related to field studies
1. What were the good and difficult things in the field studies? Make a list together and give recommendations for improvement in the future.
2. Are the farmers interested to continue parts of the study in the next season? How does the plan for study look like? Try to make a study design together and decide what will be looked at in detail?

III. Plans for further activities on peanuts
1. What are the plans of the group to help other farmers in the village understand more about peanuts? What activities are planned for next season?

Summarize the plans together. Discuss what kind of support will be needed and how it can be obtained.