Food and Agriculture Organization of the United Nations

Farmer field school curriculum

for the integrated crop management of paddy, oil seed and pulses crops in central dry zone of Myanmar

Climate-Friendly Agribusiness Value Chains Sector (CFAVC) project

Global Agriculture and Food Security Programme (GAFSP)

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Nay Pyi Taw, 2022

Required citation:
FAO. 2022. *Farmer field school curriculum for the integrated crop management of paddy, oil seed and pulses crops in central dry zone of Myanmar.* Nay Pyi Taw. https://doi.org/10.4060/cc1306en

ISBN 978-92-5-136723-0

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Abbreviations and acronyms

AESA	agroecosystem analysis
BCA	biological control agent
EIL	economic injury level
EPA	Environmental Protection Agency
ETL	economic threshold level
FAO	Food and Agriculture Organization of the United Nations
FFS	farmer field school
ICM	integrated crop management
IFDC	International Fertilizer Development Center
IRRI	International Rice Research Institute
GAFSP	Global Agriculture and Food Security Program
GAP	good agricultural practices
PPD	Plant Protection Department
WHO	World Health Organization

Farmer field school contents

Introduction

The Global Agriculture and Food Security Programme (GAFSP) in Myanmar GCP/MYA/027/GAF targeted at least 35 000 households (equivalent to 154 000 persons) living in the project (central dry zone) area including Pakokku, Magway, Aunglan, Natmauk, and Pwintbyu in Magway region; Mahlaing, Pyawbwe, Natogyi, Sintkaing in Mandalay region; and Monywa, Shwebo, Sagaing, Yinmarbin and Salingyi in Sagaing region. Based on 2015 census data, the average household size in the project area is Mandalay (4.4), Sagaing (4.6) and Magway (4.1) (MoIP (Ministry of Immigration and Population), 2015).

In the project area, 48 percent of the household are landowners and 52 percent of households are landless (11 percent of total are casual labourers, 16 percent have small livestock as their main activity and 26 percent are engaged in off-farm activities) (Boutry *et al.,* 2017). Small-scale family farmers play a major role in producing food for rural and urban populations. Farmers must adapt and fine-tune practices for growing and marketing their produce sustainably, but "ecological intensification" requires adaptive management reflecting the local context: ecological literacy and farmer collaboration are key factors (FAO, 2019a).

In Myanmar, about 70 percent of the population lives in the rural areas and majority of the people depend on rice farming for livelihood. Poverty and food insecurity pervade in the rural areas as farmers have low yields and income. Rice, groundnut, sesame, green gram and chickpea are important crops not only for local consumption but also for export in the project areas. Groundnut is an exception which doesn't meet the local demand of cooking oil. Rice, being the staple food of the people and a major exported product, remains to be the prime agricultural commodity in Myanmar. Sagaing and Mandalay regions are among the largest rice production areas of Myanmar. The rice production in the project regions (5.028 million tonnes) was about 22 percent of the national production (22.575 million tonnes) in 2018 monsoon rice growing season. The production of groundnut (*Arachis hypogaea*), sesame (*Sesamum indicum*), green gram (*Vigna radiata*) and chickpea (*Cicer arietinum*) in the project area, Sagaing, Mandalay and Magway regions was around 80 percent of the national production for each crop. Chickpea was mainly produced in Sagaing region accounting for 52.58 percent of the national production. The data clearly highlighted that the production of these five crops, i.e., paddy, groundnut, sesame, green gram and chick pea is important not only for the project area but also for the whole country. It is essential to increase the yield of these crops not only to generate more income of the farmers in the project area but also for the domestic consumption and foreign exchange earnings from the export.

The farmer field school (FFS) is a unique approach to educate farmers and improve their skills to produce crops for a market-oriented economy. FFS allows farmers to learning of complex management skills through heuristic approach in a collective manner or farmers to farmers throughout a cropping season of a particular crop. In general, FFS consist of groups of people with a common interest, who get together on a regular basis to study the *"how and why*" of a particular topic. The topics covered can vary considerably - from IPM, organic agriculture, animal husbandry, and soil husbandry, to income-generating activities such as handicrafts. The FFS starts with the rice crop but the principles and training modules can be adapted for other crops in the rice-based cropping system.

A hands-on training was recently given in Tatkon township, Nay Pyi Taw in 2019 summer season and another training in Yinmarbin township, Sagaing region in 2019 monsoon season by IRRI (IRRI, 2019). This means the Curriculum for FFS on Rice ICM (integrated crop management) was already available and recently utilised in Myanmar. Similarly, Facilitators' guide book for farmers' field schools by Parul (2017) and FFS (Upland rice), Facilitator's Handbook both in English and Myanmar language was published by Metta Development Foundation (MDF) (2015). It is not necessary to repeat the same thing for Myanmar farmers. Therefore, integrated pest management will be addressed as a general concept for all crops rather than emphasising a particular crop or a particular growth stage of each crop.

In this curriculum, integrated pest management (IPM) for these selected crops, paddy, groundnut, sesame, green gram and chickpea will be briefly outlined. The general concept of IPM will be the same for these crops although the insect pests, diseases and weeds may differ from one crop to another. The name of pests will be listed for information and important messages those are unique for Myanmar situation will be briefed if necessary, rather than giving detailed account of morphology, biology, ecology and management which can be readily available in published literature. It is aimed to improve the knowledge of farmers on the pests including insects, plant diseases, weeds and rodents causing reduction in the yield of field crops and how to manage the crops to boost the crop production without deteriorating environmental resources for sustainable agriculture.

Every year, between 400 000 and 1 million farmers participate in FFS. So far, an estimated 20 million farmers have participated in FFS over 90 countries in Asia, Africa, the Near East, Latin America and Europe. FFS have adapted to different agroecological zones, from irrigated systems

to rainfed and arid zones (FAO, 2019a). According to PPD (2020), 2 210 839 farmers were trained from the farmer field schools between 2013–2014 and 2017–2018 in Myanmar.

Bartlett (2005) suggests that the utility of the FFS to farmers is self-evident from the fact that so many have chosen to participate. However, organisational issues such as leadership, policy, human resources and competition help to explain why the IPM field school has taken off in some places and not in others. To implement the program, it is necessary to consider all fundamental elements of an FFS encompassing the group, the field, the facilitator, the curriculum, the program leader, and financing (Gallagher, 2003).

SESSION I: INTRODUCTION

Welcome and Introductions

- group norms;
- goal and objectives of the training;
- introduction to farmer field school;
- talking about farming experiences; and
- bringing it all together.

What is a farmer field school (FFS)?

The FFS is a school which takes place in the field. That is where farmers work, so that is where they will all learn. Farmers will be doing many activities and experiments in the field in order to learn better about how to grow and harvest higher quality and more field crops aiming for the goal of helping everyone earn higher income.

In fact, the farmer field school approach was developed in the late 80's by FAO in South East Asia as a way for small-scale rice farmers to investigate, and learn by themselves the skills required for adopting integrated pest management (IPM) practices in their paddy fields and the associated benefits. The approach emerged from the ecological, political and economic crises occasioned by the massive rice pest outbreaks that threatened the national food security of many countries in Southeast Asia in the late 1980s and early 1990s (FAO, 2019b). The essence of FFS is to empower farmers to learn, understand, and make informed decisions. The FFS approach challenges conventional agricultural extension approaches, which are based on top-down delivery of technology packages.

The four major principles within the FFS process are:

1. grow a healthy crop
2. observe fields regularly
3. conserve natural enemies
4. understand the ecology and become experts in the field.

The FFS should meet the following objectives (FAO, 2016):

1. introduce good agricultural (farming) practices of the selected crop;
2. improve knowledge of crop cultivation based on IPM and other concepts; and
3. empowering farmers to be decision makers.

The three educational goals of an FFS are: (1) learning takes place in the field; (2) field conditions define most of the curriculum; and (3) real field problems are observed and analysed from planting to harvesting (Okoth *et al.,* 2010).

FFS evolved initially to address the challenge of ecological heterogeneity and local specificity in pest management, by supporting ecologically-informed decision-making by farmers that would allow them to reduce pesticide use, improve crop management and secure better profit margins (Braun *et al.*, 2006). They pointed out that FFSs are not a universal panacea for development, nor are they a substitute for more familiar technology-centred or profit-driven approaches to rural development, such as extension, credit cooperatives, core-estates without growers, farmer training centres, or the use of mass media. They share some of the features of other participatory approaches, such as Participatory Technology Development, that seek to catalyse farmer-driven development.

The typical IPM field school

The following is a list of paddy IPM farmer field school basics (Pontius *et al.,* 2002). Although this is outlines for the paddy, the same principles will be applied for other crops such as groundnut, sesame, green gram and chickpea.

- The IPM school is field-based and lasts for a full cropping season.
- A rice FFS meets once a week with a total number of meetings that range from at least 10 up to 16. (The number of meeting may change with the duration of crop).
- The primary learning material at a farmer field school is the rice field.
- The field school meeting place is close to the farming plots, often in a farmer's home and sometimes beneath a convenient tree.
- FFS educational methods are experiential, participatory and learner-centred.
- Each FFS meeting includes at least three activities: the agroecosystem analysis, a special topic and a group dynamics activity.
- In every FFS participants conduct a study comparing IPM with non-IPM treated plots.

- An FFS often includes several additional field studies depending on local field problems.
- Between 25 and 30 farmers participate in an FFS. Participants learn together in small groups of five to maximise participation.
- All FFSs include a field day in which farmers make presentations about IPM and the results of their studies.
- A pre- and post-test are conducted as part of every field school for diagnostic purposes and for determining follow-up activities.
- The facilitators of FFSs undergo intensive season-long residential training to prepare them for organising and conducting field schools.
- Preparation meetings precede an FFS to determine needs, recruit participants and develop a learning contract.
- Final meetings of the FFS often include planning for follow-up activities.

During the FFS, there will be many activities to carry out the Demonstration Plot especially for the purpose of practicing good agricultural practices (GAP) and integrated pest management. It is the field for working and learning. Farmers will be doing experiments like how to reduce the use of pesticides to encourage the survival of natural enemies in the field. They will also learn how to make botanical insecticide. They will use biopesticides as much as they can for the control of pest and diseases in the field crops.

Steps in FFS

To implement an FFS program, the steps are as follows:

1. give explanation of WHAT IS A FARMER FIELD SCHOOL? to participants;
2. take QUESTIONS about FFS from Farmer Participants; and
3. activity: FFS farmers INTRODUCE themselves:

    a. All participants sit down in a large circle.

    b. Inform the entire group of FFS participants that they will have 90 seconds to introduce themselves when the ball is thrown to them. They must tell everyone their name, the types of crops they grow on their farms, and other details they choose, including one fact which no one knows.

4. NAMING small groups:

a. Divide participants into five small groups, each with five farmers. You may want to start this by having the group count off in fives (1,2,3,4,5,1,2,3,4,5….) and have all the 1s, 2s, 3s etc. form groups.

NOTE: It is probably best for the facilitator to divide the group up. This way, participants will have to associate with other farmers they do not already know, and this will result in more effective cooperation within the small group. After these groups are created, tell farmers that if they are already friends or very familiar with others in their group, they will need to change groups.

5. Questions from farmer participants about the FFS activities and practices.

NOTE: Do not take more than 30 minutes.

6. Establish RULES. The facilitator facilitates a brainstorming discussion and establishing rules for the FFS.

In order to work well with an FFS, it is necessary to be clear on what they are all going to do.

First, the Facilitator: The Facilitator will be here weekly on the same day according to the agreement. On time. With the supplies needed and prepared for the sessions on that day.

Second, the farmer trainees are to be at the FFS meeting place weekly on the right day at the right time. Farmer, himself or herself. Not a substitute (like son or a friend). Farmers are expected to be serious about learning at the FFS, because FFS intends to provide farmers with a powerful learning experience that has transformed the lives of them. Farmers will be working and learning in small groups, and will have to cooperate in your small groups.

Rules

Tell the farmers, “It is very important for all participants to respect a common set of rules. Rules that are imposed by outsiders will not be enforced here. This school will be run by rules created mainly by you, the participants/owners. What rules do you want for this group?” Write down all the answers on the flipchart and discuss with the group whether each item is appropriate.

The following topics should be discussed:

- when will we meet? what time?
- respect
- participate
- cell phones
- be on time
- how will we deal with people who are late?
- we will meet even if it rains!
- when is absence tolerable? only in case of emergency.

Although FFS has made its own rules, there are some nonnegotiable rules that all participants must follow:

  - to graduate, one can miss only one session; and
  - display this FFS rules sheet at every subsequent session.

In this session, all participants will be asked to brief about their farming system on their land. Each farmer will be given one or two minutes just to talk about their family size, their education level, landholding, the cropping pattern, the allocation of different crops main, source of income other than crop cultivation. Ask them what their expectation is to participate in this FFS on IPM/ICM.

Then the facilitator will explain the meaning of farmer field school, the history and development in different parts of the world, the objectives and the procedures through a cropping season, and finally the rules to follow by all participants.

Finally, the facilitator should sum up all the information and fix the date for next session.

SESSION II: BASIC KNOWLEDGE AND CURRENT PRACTICES OF CROP PRODUCTION

Review of previous topic

- common practices of crop production, GAP, organic farming;
- the role of seed in crop production introduction to farmer field school;
- the role of fertilisers in crop production;
- the role of pesticides in crop production; and
- the overview of farmers practices and problems.

In this session, the facilitator needs to brief about the discussion from the first session. After that, the participants will be encouraged to narrate individually the practical experiences of crop production on their land. They will be asked questions to assess their basic knowledge and current practices of crop production. The sample questions will be as follows.

- What type of cultivation method do you use?
  - broadcasting
  - line sowing
  - intercropping/mixed cropping
  - crop rotation.
- why do you use these methods?
  - what are the advantages?
  - what are the disadvantages?
- Do you know about good agricultural practices (GAP)?
  - If the answer is yes,

    Have you ever practiced it?

    If not yet, are you interested to practice it?
  - If the answer is no,

    Explain about good agricultural practices (GAP).
- Do you know about organic farming?
  - If the answer is yes,

    Have you ever practiced it?

    If not yet, are you interested to practice it?

- If the answer is no,

  Explain about organic farming.

You may also talk about some other practices such as conservation agriculture, moisture harvesting, windbreak, etc. if time is available.

The role of seed in crop production

- Ask the farmers about the seeds they used on their farm?
  - Where do you get your seeds from?

    Own seed, from DoA (Department of Agriculture), DAR (Department of Agricultural Research), seed company or agro input dealers?
  - How long have you been using these seeds?
  - How often do you introduce new seed variety?
  - Any problems with seeds after using continuously for many years?
  - Do you know about hybrid seeds and have you ever used it?

After that, the facilitator needs to explain the importance seeds for crop production. It is also necessary to brief about the nature of hybrid seeds.

The role of fertilisers in crop production

- Ask the farmers about the fertilisers they used on their farm?
  - What type of fertiliser do you use?

    Chemical fertiliser (compound or straight), cow-dung, animal waste or biofertiliser?
  - Where do you get the fertilisers from?

    From agrochemical companies, DoA or any other source?
  - Who recommend you to use it?
  - Do you follow their advice?
  - How many years continuously have you been using them?
  - What are the advantages of using them?
  - What are the consequences of using them?

After that, the facilitator needs to explain the role of fertilisers for crop production and the consequences (deteriorating soil fertility rather than improving it) if the use of nutrients is imbalance.

The role of pesticides in crop production

- Ask the farmers about the pesticides they used on their farm?
    - Have you ever used any pesticides in your field?
    - Do you know insecticide, fungicide and herbicide?
    - What type of pesticides do you use?
      Chemical pesticides / natural or botanical pesticides / biopesticides?
    - Where do you buy the pesticides from?
    - Who recommend you to use it?
    - Do you follow their advice with the choice of pesticide, the dosage and frequency, when to apply?
    - How many years have you been using them continuously?
    - Are they working? What are the advantages of using them?
    - What are the consequences of using them?
    - Any problem with the pesticide poisoning?

At the end of the session, the facilitator needs to explain the classification of pesticides, the advantages and disadvantages of using them, safe and efficient not to create unwanted problems in the long run.

SESSION III: PEST INSPECTION AND DIAGNOSIS

Review of previous topic

- insect pests of field crops;
- plant diseases of field crops;
- what is past knowledge and experience on them?; and
- how do you tackle them? pest control.

Review of previous topic

In this session, the facilitator needs to brief about the discussion from the previous session. After that, the participants will be encouraged to narrate individually the practical experiences of insect pest infestation in their crops. They will be asked questions to assess their basic knowledge and current practices of crop protection. The sample questions will be as follows.

- What types of insects were found in your crops?
  - On which part of the crop do they feed?
    On the leaf, on the stem, at the base of the plant, the roots, or internal feeders?
  - Please name them (local names).
  - Which one is the most serious?
  - How much damage do they cause to the crop?
  - The injury and yield loss due to their feeding.
  - How do you control them?
    I use chemical insecticides.
    I use botanical insecticides.
    I do nothing.
- Do you think all insects and spiders found in your crops are pest?
  - Are they harmful to your crop?
  - After the application of insecticides, what happen to them.
- What type of plant diseases were found in your crops?
  - Do you see the symptoms on which part of the crop?
    On the leaf, on the stem, at the base of the plant, the roots, or the whole plant?
  - Please name them.

- Which one is the most serious one?
- How much damage do they cause to the crop?
- The symptoms and yield loss due to the disease.
- How do you control them?

  I use fungicide.

  I use bactericide.

  I use inorganic compound.

  I do nothing.

- Do you think the disease incidence is related to weather condition?
  - More serious in monsoon season.
  - More serious in winter/cool season.
  - More serious when raining/cloudy.
  - After the application of insecticides, what happen to them.

The facilitator should encourage them to share their experience with insect pest and disease in their crop and how to manage/control them not to affect the yield of crops. After that, the facilitator should give a brief account of insect pests and plant diseases commonly occurred on each crop, how to identified insect pests and disease based on the symptoms observed on the crop. Easy or simple way of diagnosis should be given to the farmer with their own language to make them fully understand.

Based on the feedback of the farmers, some detailed account of pests and diseases which were endemic to the region and difficult to control should be given. Integrated management system or successful story in other part of the country or somewhere else should be explained in detail.

Farmer should be asked to search for the insect pests and diseases in the filed for about half an hour and educate them the difference between the symptom of insect and disease. It is important to tell them not all insect are pests in the crop. Some of them are beneficial and helping them to suppress the pests in the field. Pictorial guide or live specimen will be needed to make them remember and able to discriminate between friends and enemies.

The following guideline can be given as a reference.

Flow model diagnosing plant damage:

I. DEFINE THE PROBLEM (Determine that a "real"problem exists):

A. **Plant identification and characteristics.** Establish what the "normal" plant would look like at this time of year. Describe the "abnormality": symptoms & signs.

B. **Examine the entire plant and its community.** Determine the primary' problem and part of the plant w here initial damage occurred.

II. LOOK FOR PATTERNS: On more than one plant? On more than one plant species?

A. **Non-uniform damage pattern-!** scattered damage on one or only a few plant species) is indicative of *living factors* (pathogens, insects, etc).

B. **Uniform damage pattern** over a large area (i.e., damage patterns on several plant species) and uniform pattern on the individual plant and plant parts indicates nonliving factors (mechanical, physical, or chemical factors.)

III. DELINEATE TIME-DEVELOPMENT OF DAMAGE PATTERN:

A. Progressive spread of the damage on a plant, onto other plants, or over an area with time indicates damage caused by living organisms.

B. Damage occurs, does not spread to other plants or parts" of the affected plant.' Clear line of demarcation between damaged and undamaged tissues. These clues indicate nonliving damaging factors.

IV. DETERMINE CAUSES OF THE PLANT DAMAGE Ask questions and gather information.

A. distinguish among living factors:

1. Symptoms and signs of PATHOGENS; and
2. Symptoms and signs of INSECTS, MITES, and OTHER ANIMALS.

B. distinguish among nonliving factors:

1 MECHANICAL FACTORS

2 PHYSICAL FACTORS

   a. temperature extremes
   b. light extremes
   c. oxygen and moisture extremes.

3. CHEMICAL FACTORS:

   a. analyse damage patterns in fields and other plantings;
   b. injury patterns on individual plants;
   c. pesticide-pollutant phytotoxicities - damage patterns; and
   d. nutritional disorders -key to nutritional disorders.

C. references (check reports of damaging factors on identified plant); may need.

Source: Green (1990)

Simple check for the symptoms to identify pest, disease or other causes

Symptoms **Change in growth** **Changes in appearance** **Dead plant parts**	**Signs** **Evidence of a pest** **Actual insect** **Observe mechanical damage** **Secretions from the plant** **Damage pattern**
Holes in tissue - insect **May be large or small, ragged or precise** **Most common** **Caterpillars or beetle** **Grasshopper** **Look for frass** **Caterpillars may produce webbing**	**Skeletonizer - insect** Only eat top surface (green parts) of leaf **Shot hole** beetle **Leaf mines** Leaf miner
Leaf spots **Brown, black, tan, purple, yellow, red** **Usually with a halo - disease**	**Leaf spots** May be caused by insect feeding on back of leaf
Discoloration **Interveinal chlorosis** **Yellow tissue between the vein** **New growth only - Iron deficiency**	
Causes of plant problems **Nonliving causes** **Abiotic problems** **-weather** **- herbicide injury** **- soil compaction**	**Living causes** Biotic problems - pathogen - Insects - other microorganisms

SESSION IV: PEST INSPECTION AND DIAGNOSIS (Continued)

Review of previous topic

- common weeds in field crops;
- rodents in field crops;
- what is past knowledge and experience on them?; and
- how do you tackle them? pest control.

Review of previous topic

In this session, the facilitator needs to brief about the discussion from the previous session. After that, the participants will be encouraged to narrate individually the practical experiences of weed and rodent problem in their crops. They will be asked questions to assess their basic knowledge and current practices of crop protection. The sample questions will be as follows.

- What types of weed were found in your crops?
  - When do you find them?

    At land preparation, after the crop emergence, early stage of crop growth or later stage of crop growth?
  - Please name them (local names).
  - Which one is the most serious?
  - Does it affect plant growth processes?
  - Does it affect the yield and quality of product (seed)?
  - How do you control them?

    I use herbicides.

    I use hand weeding.

    I use inter-cultivation.

    I do nothing.
- What types of rodents were found in your crops?
  - Do you see the symptoms on which part of the field?

    Near the bund, in the middle of the field, on a certain area where there is no water?
  - Please name them (local names).
  - Which one is the most serious?

- Do you know the biology of rodents?
- How much damage do they cause to the crop?
- Does it affect the yield and quality of product (seed)?
- How do you control them?
    - I use rodenticide.
    - I use trapping.
    - I do hunt with dog.
    - I do nothing.

The facilitator should encourage them to share their experience with weed and rodent problem in their crop and how to manage/control them not to affect the yield of crops. After that, the facilitator should give a brief account of weeds and rodents commonly found in low land and upland crops. Easy or simple way of explanation should be given to the farmer with their own language to make them fully understand.

Based on the feedback of the farmers, some detailed account of weeds and rodents which were endemic to the region and difficult to control should be given. Integrated management system or successful story in other part of the country or somewhere else should be explained in detail.

Farmer should be asked to search for the weeds and rodents in the filed for about half an hour. When they come back with the specimens especially with weeds, ask them to identify by themselves and make them share their experiences how they have tackled the problems.

Some farmers may have good experience with using herbicides in their crops so as they have solved the problem of labour shortage in the field due to migration. However, they should be educated to be able to use herbicide efficiently and safely in their field.

Weeds can be classified by

(1) Life span: (a) annual weeds which complete their life cycle in less than one year, and (b) Perennials- plants that may live more than two years.
(2) Habitat: (a) aquatic – plants that emerge and grow in very wet or flooded soil, (b) semi-aquatic- dry land plants that has some tolerance to sub mergence, (c) terrestrial – dryland plants, and (d) parasitic – depend on other plants to take nutrient.

(3) Morphology: (a) grasses – round hollow stems with solids nodes, (b) sedges – with solid, triangular or round stem, usually no nodes, and (c) broadleaved weeds –expanded leaf blade and have various shape.

Crop and weed are growing in close proximity to one another and the supply of growth factors fall below the demand of both. Weed competition is greatest in the first 30-40 days after seeding or transplanting. During this period weeds should be removed to prevent yield losses due to weed competition. Thus, the first 30 percent of the life cycle of the crop is the best time to control weeds to prevent yield reduction due to competition. Plant Protection Division (PPD), Myanmar has recommended 29 active ingredients of herbicides to control weeds in different crops.

Herbicides are classified according to time of application as follows:

1. Pre-plant

- Foliar application
  The herbicides is sprayed on the existing vegetation to kill weeds before planting, e.g., Glyphosate, Paraquat
- Soil incorporation
  The herbicide is incorporate into the soil.

2. Pre emergence

The herbicide is applied to the soil surface before emergence of the crop or weeds, e.g., Pretilachlor, Butachlor.

3. Postemergence

Herbicide application after emergence of particular crops or weeds. e.g., 2,4-D

Rodent search in the field

Finding rodent in the field within a short period may not be possible but they can find damage symptoms in the field. The biology of rodent biology and their management strategy should be explained. It should be highlighted that rodent are prolific and they can reproduce many times within one crop season.

There are four kinds of rodent mostly found in Myanmar Agriculture.

- rats and mice
- bamboo rats
- squirrels
- porcupines.

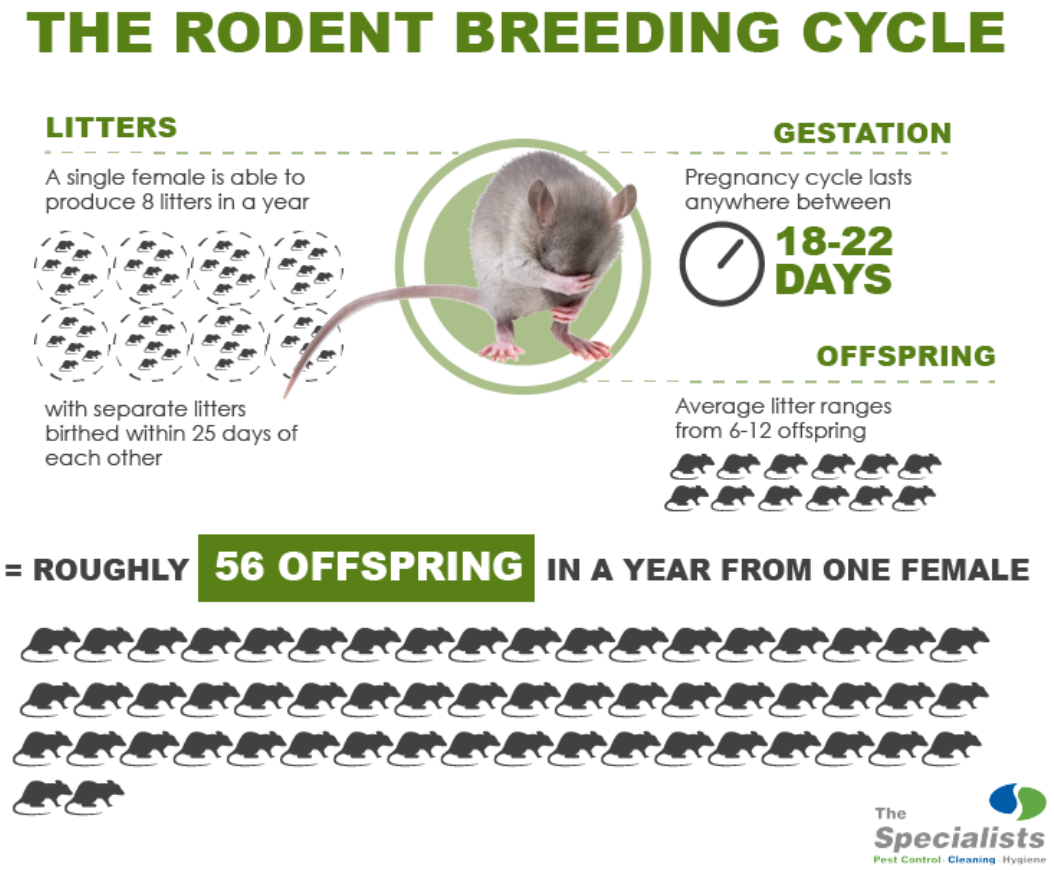
In different parts of Myanmar, different species of rodents were found. Seventeen species of rodent have been collected in Myanmar. The most commonly found rodent species reported by Nyo Me Htwe (2013) were:

- *Bandicota savilei;*
- *Bandicota bangalensis;*
- *Rattus rattus complex;*
- *Mus musculux* and
- *Mus cervicolor.*

The breeding of the rice field rat is linked to the development of the rice crop and they give birth to 10-14 young. They begin breeding before panicle initiation and stop when the crop ripens. If crops are planted more than two weeks apart then the rats will move to the late-planted crops and continue breeding. The rice field rat has an equivalent number of breeding season with the number of rice planting season per year. That means one crop, one breeding season and two crops, two breeding seasons and so on.

Female rats are pregnant for 21 days and they can mate the day after they give birth. One female can give birth to three litters (12 young per litter) in one planting season resulting in a total of 36 rats. These young will not breed until a next crop unless a neighboring farmer plant their crops more than two weeks apart. Then this will extend the breeding season of the rats throughout the year. Six females from the first litter will breed at seven weeks of age. One adult female rat could potentially give rise to 120 rats in a single rice growing season (Singleton, 2003). However, some sources said, one female rodent can produce 56 offspring in a year (see below).

Morris (1999) has given a practical exercise how important is the population dynamics of rodent to work out by the farmers.



Source: the specialists pest control cleaning hygiene

Based on the feedback of the participants, the control measures commonly adopted by the farmers could be understood. Some video clip should be played to make farmer understand the biology and control of rice-field rat.

Rodenticides

In Myanmar, five different active ingredients; zinc phosphide, brodifacoum, bromadiolone, flocoumafen and warfarin, were registered with 20 different names by different agochemical companies (PPD, 2020). Among them, zinc phosphide is an inorganic compound used as rodenticide baits. When an animal eats the bait, the acid in the animal's stomach turns the zinc phosphide into phosphine which is a very toxic gas.

Warfarin is a multiple-dose anticoagulant. A rat needs to eat multiple doses of the bait over several days. Brodifacoum and bromadiolone are single dose anticoagulants and they are more toxic and one day's feeding can deliver a toxic dose (NPIC (National Pesticide Information Center), 2016).

The second-generation rodenticide such as brodifacoum and bromadiolone were allowed to register by changing formulation type. However, the use of Mandalar 2 (bromadiolone) was not encouraged by PPD, Myanmar (Dr Nyo Me Htwe, pers.comm. 2020). Mandalar 2 is meant for using only in closed environment, not allowed to use open environment.

SESSION V: INTEGRATED PEST MANAGEMENT

Review of previous topic

- the basic concept of integrated pest management;
- farmers' understanding of IPM;
- the role of pesticides in crop production; and
- some examples of success stories in the region / other area.

Review of previous topic

In this session, the facilitator needs to brief about the discussion from the previous session. After that, the facilitator should explore the prior/basic knowledge of integrated pest management/ integrated crop management before they join the FFS. Individual participant needs be questioned as follows:

1. What were the major pests and diseases in your farm for the past five years?

		Is pesticide use a solution?	
Major pests	**Major diseases**	**Yes**	**No**
1.	1.	☐	☐
2	2.	☐	☐
3.	3.	☐	☐

2. How you feel about the current pests and diseases situation or problem in your area?
☐ I have no problem
☐ Low and manageable
☐ Difficult to manage

3. Do you always apply pesticides when you have problem with pests?
☐ Yes, ☐ No,

4. Do you look for pests on the plants before spraying?
☐ Never
☐ Yes, daily
☐ Yes, approx. weekly
☐ Yes, approx. monthly

5. Do thresholds exist for the major pests on your main crop?
☐ Yes, ☐ No, ☐ I don't know,

6. Do you know what IPM (integrated pest management) is?

☐ 1 *I have never heard of IPM*

☐ 2 *I know the term IPM and have a vague idea of what it means*

☐ 3 *I have a good understanding what IPM is*.

7. What specific practices are you aware of (have you heard about?) And which are you implementing for this crop? *(Please tick 'Yes' for positive responses. Leave blank for 'No' or 'don't know & not relevant"?)*

	Do you know?	Do you use this technique?	If not using now, do you want to use it?
	Yes	Yes	Yes
1. Field sanitation	☐	☐	☐
2. Crop rotation	☐	☐	☐
3 Mixed cropping / intercropping	☐	☐	☐
4. Removal of volunteers and alternative hosts of pests and diseases	☐	☐	☐
5. Ploughing to expose pupae	☐	☐	☐
6. Ploughing to bury crop residues	☐	☐	☐
7. Improving habitats for natural enemies (Ecological Engineering)	☐	☐	☐
8. Use of certified seeds / planting material	☐	☐	☐
9. Resistant / tolerant varieties	☐	☐	☐
10. Use of pheromone traps for monitoring	☐	☐	☐
11. Record keeping for monitoring	☐	☐	☐
12. Application of pest thresholds	☐	☐	☐
13 Removal and destruction of affected plant parts	☐	☐	☐
14. Hand picking of eggs and larvae	☐	☐	☐
15. Use of sticky / light traps	☐	☐	☐
16. Use of biological control agent (predators and parasitoids)	☐	☐	☐
17. Use of biopesticides (e.g. *Bacillus thuringiensis*)	☐	☐	☐
18 Use of commercial botanical pesticides (e.g. neem oil)	☐	☐	☐
19. Post-harvest (storage) application of chemical pesticides	☐	☐	☐
20. Others *(please specify)*	☐	☐	☐

8. Do you apply the following traditional practices? Do you consider those practices to be effective? *(Please tick Yes or No; tick both boxes if they are only partially effective)*

traditional practice	Apply		Effective		
	Yes	No	Yes	No	Partially
1. Field application of homemade botanical (plant-based) pesticides	☐	☐	☐	☐	☐
2. Field application of non-botanical homemade pesticides (ashes, dust, soap…)	☐	☐	☐	☐	☐

9. Are you interested to change your farming practices (e.g., to use less pesticides with the concept of IPM if you receive (more) training?

☐ Yes ☐ No ☐ I don't know

Integrated pest management (IPM)

A pest is defined as any species, strain or biotype of plant, animal or pathogenic agent injurious to plants and plant products, materials or environments and includes vectors of parasites or pathogens of human and animal disease and animals causing public health nuisance (FAO/ WHO, 2014). Pest control /management practices involve:

1. cultural control
2. mechanical and physical control
3. use of resistant varieties
4. chemical control
5. biological control.

Cultural controls: Cultural controls are practices that reduce pest establishment, reproduction, dispersal, and survival. For example, changing irrigation practices can reduce pest problems, since too much water can increase root disease and weeds.

Mechanical and physical controls: Mechanical and physical controls kill a pest directly, block pests out, or make the environment unsuitable for it. Traps for rodents are examples of mechanical control. Physical controls include mulches for weed management, steam sterilisation of the soil for disease management, or barriers such as screens to keep birds or insects out.

Use of resistant varieties: Host plant resistance (HPR) to insects is an effective, economical, and environment friendly method of pest control. Some varieties of crops are tolerant or resistant to the insect pest or plant disease when some other varieties were vulnerable to pest attack and causing severe damage under the same environmental conditions. Host plant

resistance (HPR) can be used alone or in combination with other tactics, to reduce the impact of herbivores on crop yield or quality.

Chemical control: Chemical control is the use of pesticides. In IPM, pesticides are used only when needed and in combination with other approaches for more effective, long-term control. Pesticides are selected and applied in a way that minimises their possible harm to people, non-target organisms, and the environment.

Biological control: Biological control is the use of natural enemies—predators, parasites, pathogens, and competitors—to control pests and their damage. Invertebrates, plant pathogens, nematodes, weeds, and vertebrates have many natural enemies.

Pest management is the intelligent selection and use of pest control actions that will favourable economic, ecological and sociological consequences. The practice of pest management has been described by Geier (1966) as: (1) determining how the life system of a pest needs to be modified to reduce its number to a tolerable levels, that is, below the economic threshold, (2) applying biological knowledge and current technology to achieve the desired modification, that is, applied ecology, and (3) devising procedures for pest control suited to current technology and compatible with economic and environmental quality aspects, that is economic and social acceptance. An integrated pest management approach should be ecologically sound, economically profitable and socially acceptable.

According to the National Academy of Sciences, IPM refers to an ecological approach to pest management that consolidates all available necessary techniques in a unified programme to manage pest populations in order to avoid economic damage and minimise adverse side effects (NAS (National Academy of Science), 1969).
The IPM concept is based on the principle that it is not necessary to eliminate all pests but to reduce pest populations to levels where pests cannot cause significant loss. An integrated pest management strategy includes use of pest-resistant crop varieties, modifying agronomic practices to reduce pest incidence, biological control along with other innovative approaches to pest suppression and need-based judicious use of chemical pesticides.

These IPM principles and practices are combined to create *IPM programs*. While each situation is different, five major components (Stein, 2006) are common to all IPM programs:

1. identify the pest
2. monitor pest activities
3. determine action thresholds

4. explore treatment options and make treatments
5. evaluate results.

Activities:

Paddy insect pest management: brown plant hopper (BPH):

The adult hopper is brown colored • It may be long winged (macropterous)or short-winged (brachypterous). • Both adult & nymph suck sap from the Stem. • It is a serious pest of rice.	
Damage Symptom • Nymphs are whitish and gradually tuning brown. • Both adult and nymph crowded at the base of the rice plant and suck sap from stem. • Direct feeding by a large number of hoppers causes the plants to dry up and is known as hopper burn.	
BPH transmit Grassy Stunt and Ragged stunt virus diseases	
Control Measures • light trapping; • using wider plant spacing; • draining out of water; • avoidance of top dressing of N fertiliser in endemic areas; • cultivation of early maturing varieties; • cultivation of BPH resistant variety; and • insecticide should be applied, if 2–4 gravid female or ten nymph/hill are present in 50 percent hill.	

Groundnut Insect Pest Management: Groundnut leaf miner and binder (GLMB):

Morphology The adult moth is dark brown colored • It is about six mm long with ten mm wing span, forewings with white spots on the costal margin • It is a serious pest of groundnut	
Damage Symptom • Larvae are green in colour with dark head and prothorax • The larvae mine into the leaves and feed the green tissues inside • Severely attacked field looks “burnt” from a distance	
Severely attacked plants loss the photosynthesis power and the yield reduced	
Control Measures • Use resistant cultivar -Sinpadetha -1 • Set light traps 12/ha • Hand picking • Spray with water to drown the larvae inside the binding leaves	

• Apply fenvalerate 100 ml a.i./ha or indoxacarb 70 ml a.i./ha or spinosad 45 ml a.i./ha if defoliation exceeds 25%, or if one or more larvae per plant is observed during the first 50 days after seedling emergence (DAE).	

Sesame Pest Management: Sesame Phyllody - Phytoplasma:

Introduction • This disease is caused by phytoplasma • Transmitted by *Orosius albicintus* leaf hopper • Severe in premonsoon crops **Damage Symptom** • All floral parts are transformed into green leafy structures followed by abundant vein clearing in different flower parts. • In severe infection, the entire inflorescences is replaced by short twisted leaves closely arranged on a stem with short internodes, abundant abnormal branches bend down. • Finally, plants look like witches' broom. • If capsules are formed on lower portion of plant, they do not yield quality seeds.	
Severely infected crop suffers remarkable yield losses as there is no fruiting process	
Control Measures • Use resistant varieties recommended by DAR • Remove and destroy infected plants • To control vector, spray Dimethoate 30 EC 500 ml/ha combined with intercropping of Sesamum + pigeon pea (6 : 1) • Quinalphos 25 percent EC 2000 ml/ha	

Green gram insect pest management: green gram pod borer, *Maruca testulalis*:

Morphology • **Larva -** greenish white with brown head. It has two pairs of dark spots on the back of each segment • **Adult - forewings**- light brown colour with white markings; **Hindwings** – white colour with brown markings at the lateral edge **Damage symptom** • defoliation in early stages; • larva's head alone thrust inside the pods and the rest of the body hanging out; and • pods with round holes.	
Severely infected crop suffers remarkable yield losses as the flowering parts and fruiting bodies are attacked	

Control Measures • **ETL:** 3/plant; • stomach/contact/systemic insecticide at flowering stage; • neem extract after pod formation; and • when the activity of coccinellid predator (both grubs and adults) is seen, insecticide application should be avoided.	

Chickpea Insect Pest Management: Gram pod borer, *Helicoverpa armigera*:

Morphology • **Eggs** – are spherical in shape and creamy white in colour, laid singly. • **Larva** - shows colour variation from greenish to brown. Green with dark brown grey lines laterally on the body with lateral white lines and also has dark and pale bands. • **Pupa** – brown in colour, occurs in soil, leaf, pod and crop debris • **Adult** - light pale brownish yellow stout moth. Fore wing grey to pale brown with V shaped speck. Hind wings are pale smoky white with a broad blackish outer margin. **Damage Symptom** • defoliation in early stages; • larva's head alone thrust inside the pods and the rest of the body hanging out; and • pods with round holes.	
Severely infected crop suffers remarkable yield loss as there is no fruiting process	
Control Measures **ETL:** 10 percent of affected pods: • pheromone traps for *Helicoverpa armigera* 12/ha; • mechanical collection of grownup larva; • azadirachtin 0.03%WSP 2500-5000 g/ha; • *Bacillus thuringiensis* var kurstaki (3a,3b,3c) 5%WP 1000-1250 g/ha; • emamectin benzoate 5%SG 220 g/ha; • indoxacarb 15.8%SC 333 ml/ha; and • spinosad 45%SC 125-162 ml/ha.	

The role of pesticides in crop production

Insecticides are the most powerful tool available for use in pest management. They are highly effective, rapid in curative action, adaptable to most situations, flexible in meeting changing agronomic and ecological conditions. Pesticide use is indispensable in agricultural production as approximately 9 000 species of insects and mites, 50 000 species of plant pathogens, and 8 000 species of weeds damage crops globally causing an estimated loss of 14 percent, 13 percent and 13 percent by insect pests, plant pathogens and weeds, respectively (Pimentel, 2009). However, excessive and non-judicious use of insecticides has led to the degradation of environmental quality, pest resistance, pest resurgence and the contamination of agricultural products and natural resources.

Some advantages and limitations of insecticides were explained in detail by Metcalf (1975).

Advantages of insecticides for pest management:

a. Insecticide affords the only practical control measure for insect pest populations approaching or at the economic threshold.
b. Insecticides have rapid curative action in preventing economic damage.
c. Insecticides offer a wide range of properties, uses and method of application to pest situations.
d. The use of insecticide is low in cost and results in substantial financial returns.

Limitations in the use of insecticides for pest management

a. insect resistance to insecticides
b. outbreaks of secondary pests
c. adverse effects on non-target species
    - natural enemies
    - honeybees and other pollinators
    - effects on wildlife.
d. hazards of pesticide residues
e. direct hazards from insecticide use.

To get the background knowledge of farmers on pesticides, farmers should be asked some questions, for example:

a. What type of pesticide do you use?
- contact poison/stomach/systemic poison
- organophosphate / carbamate / pyrethroid /neonicotinoid or any other
- insecticide / fungicide / bactericide/ nematicide/ herbicide
- i don't know.

b. When do you apply them?
- As soon as I see the insects in my field.
- Some times after I see the insects in my field.
- When the population increased?

c. What type of sprayer you use?
- hand operated
- battery type
- motorised.

d. How do you decide to apply?
- fixed schedules (calendar spraying)
- based on pest presence
- based on thresholds
- other.

e. How many times applied per crop/season?
- only one or two times
- more than five times.

f. What is the volume of spray /acre?

- low volume (20 liters x 5)
- high volume (20 liters x 10 or more).

g. What is the dosage?
   - as mentioned on the label
   - as recommended by the extension staff/ agrochemical dealer
   - higher dose/lower dose.

h. Does it work?
   - Yes, it does.
   - No, it doesn't.
   - It creates more problems.

i. Any cases of pesticide poisoning?
   - yes
   - no
   - i don't know.

j. How do you dispose the empty pesticide containers?
   - throw away
   - burn them
   - bury in the soil.

k. Do you use personal protective equipment?
   - yes
   - no
   - partially.

After getting feedback, farmers should be briefed the classification of pesticides (based on the pest, based on the chemical group, based on the mode of action), the advantage and limitations of pesticides, safe and efficient use and how to dispose the empty containers properly. The precautions for safe handling should be highlighted with illustrations.

SESSION VI: AGROECOLOGICAL SYSTEM ANALYSIS (AESA)

Review of previous topic

- the basic concept of agro-ecological system analysis;
- farmers' understanding of AESA; and
- practical application of AESA knowledge in the field.

In this session, the concept of economic threshold (ETL) will be introduced to the famers. However, the technical terms and concept may be not easy to understand. You may need to take time to make them understand. Due to the limitations of the ETL in practical application, the concept and use of agroecosystem analysis (AESA) becomes popular.

Agroecosystem analysis (AESA)

Globally IPM underwent several changes over the years in its focus and approaches, namely damage threshold, EIL, ETL and currently standardised as AESA-based IPM, which has gained universal acceptance (Uniyal, 2015). In 2002, FAO defined IPM as the careful consideration of all available pest control techniques and the subsequent integration of measures that discourage development of pest populations and keep pesticides and other interventions to levels acceptable from an economic, environmental and public health perspective. IPM emphasises healthy crop growth with the least possible disruption to agroecosystems and encourages natural pest control mechanisms. AESA-based IPM is being promoted by FAO.

The AESA approach can be easily used by extension functionaries and farmers to analyse field situations with regard to pests, defenders, soil conditions, plant health and climatic factors, and their interrelationship for a healthy crop. A critical field analysis will help in taking appropriate decisions on pest management practices.

Activities in this session will include:

- **Agroecosystem analysis (AESA).** FFS participants observe and monitor all elements of the agroecosystem and farm and learn how to make management decisions. They work in small groups and collect all the data on their experiments. Each group prepares a poster to summarise the findings, discuss the situation observed and present management options. Participants debate the proposed options and agree on the best. FFS facilitators ensure full participation and help the group reach a sound

technical decision. The collective recommendations are implemented in the learning plot, and the process is repeated throughout the season.

- **Group dynamics activities.** These are used as icebreakers and to learn about teamwork. They enhance group cohesion and make learning more fun.
- **Special topics.** Through the "topic of the day", participants gain in-depth knowledge about specific issues. A wide range of topics may cover technical issues or any subject of importance to the group, such as basic business skills, nutrition and gender roles. For example, "setting up an insect zoo" is a discovery learning process that teaches about functions of insects and about predation: pests and their natural enemies are put together in a vial, and farmers observe what happens.

The concept and activities of agroecosystem analysis (AESA)

The concept and activities of Agroecosystem analysis (AESA) as outlined by Parul (2017) can be briefed as follows:

Concept of AESA:

- Ecology is the relationship between life and environment, and Agro-ecology is the ecology in relation to agriculture.
- Ecosystem - is an interacting system in which an organism lives with other and cannot live with the absence of other (when it relates of agriculture is called agroecosystem).

Components of AESA:

- plant health at different stages;
- built-in compensation abilities of the plant;
- pest and defender population dynamics;
- soil conditions;
- climatic factors; and
- farmers' experience, etc.

Benefit of AESA:

- AESA provides a better understanding of plant health at different stages, built-in compensation abilities of the plant, pest and defender population dynamics, soil conditions, climatic factors, farmers' experience, etc.
- It helps to know the current status of above components.
- Through AESA, farmer could be able to take appropriate measures at different stages of plant growth.
- It empowers farmer to make efficient decision maker for better farm practices.
- AESA is an environment friendly practice that ensures and sustainable eco-system.

Objectives of AESA:

- Assurance of a better yield.
- Learning process by seeing and doing.
- Provide a good understanding about the inter relation of the elements of agroecosystem resulting an awareness about the influence of the same.
- AESA helps farmers in taking decision for integrated crop management by observing and analysing field situation.

Materials needed for conducting AESA

- notebooks and pens/pencils for each person
- ruler or measuring tape-one per group
- magnifying lens – one or two per group
- collection materials
- artist brush for small or delicate fauna
- aspirator made from tubing and collection vials
- sweep nets
- containers for storing samples of fauna found in plots
- vials or jars and plastic bags.

Materials needed for the presentation of AESA

- plain sheets 100cm x 50cm, e.g., newsprint or flip chart paper
- drawing material
- markers of varying colours (one set per group)
- colored pencils or crayons
- eraser and ruler
- board for displaying drawings or flip chart board.

AESA methodology

A. Field observation

i. Enter the field at least 1.5 m away from the bund. Select a 1 m2 area at random.

ii. Record visual observations in the following sequence:

a. flying insects (both pests & defenders);

b. close observation of pests and defenders on plants;

c. observe pests like borer and BPH and defenders like coccinellid, Chrysopa lacewing, ground beetle/rove beetle and earwigs, by scraping the soil surface around the plants;

d. Record disease and its intensity; and

e. Record insect damage and disease incidence as percentage.

iii. Record parameters like number of leaves, plant height and reproductive parts of selected plants for making observation in the ensuing weeks. Observe nematode damage symptoms.
iv. Record types of weeds, their size and population density in relation to crop plant.
v. Record soil conditions, namely flooded, wet or dry.
vi. Observe rodent live burrows.
vii. Record climatic factors, namely sunny, partially sunny, cloudy or rainy for the preceding week.

B. Drawing

- First draw the plant with actual number of branches/leaves etc. at the center on a chart.
- Then draw pests on left side and defenders on the right side of the plant.
- Indicate the soil condition, weed population, rodent damage, among others.
- Use natural colours, for instance, green for a healthy plant and yellow for a diseased plant or leaves.
- Care should be taken to place the pests and defenders on the part of the plant where they were observed.
- The common name of the pest should be indicated on the diagram.
- Weather conditions should be depicted appropriately, for example by the figure of a sun just above the plant to indicate sunny conditions. Clouds indicate cloudy conditions while a sun half-masked by clouds, indicates partially sunny conditions.

C. Strategy for decision-making

Some defenders like lady bird beetles, ground beetles, rove beetles and wasps play an important role in determining the P:D ratio. Detailed information on observation, analysis and decision-making can be available from FAO (2012).

Some subject areas for AESA are:

- AESA, pests and diseases
- AESA, natural Enemies
- AESA, understanding Pesticides
- AESA, insecticide effect on insects, insect damage, prevention
- AESA, weather effect on crop, disease and insect development
- AESA, post-harvest technology
- AESA, harvesting, marketing, economic analysis of crop.

Setting insect zoo for the study of insect pests and their natural enemies:
Many questions about insects can be answered by setting small experiments in an insect zoo. Use transparent boxes with fresh leaves. Or use potted plants inside a small cage. Always make sure that the insects have fresh food. Keep the zoo in a shaded place to avoid high temperature. Take care that the environment inside the zoo does not get too dry or too humid.

Assign responsibility for the zoo to one or more farmers. They have to make sure that the insects have sufficient food, and they have to make daily observations.

Use insect zoos for:

Study the life cycles of insects

- Keep caterpillars and see how they feed and how they pupate and develop to adult butterflies.

Study feeding behavior of insects

- What do they eat?
- How do they eat?
- How much do they eat?

Study predators

- How do they feed?
- How many insects can they eat in one day?

Study parasitoids

- Keep larvae and pupae of insects and see if they are parasitised.

Other experiments

- For example, study the effect of Bt (insect don't die quickly but they stop feeding).

The detailed account of studying predators in the field and in insect zoo is given by Morris (1999) in the "Facilitator's manual for the farmer field school on integrated pest management" in dry zone area of Myanmar.

SESSION VII: INTEGRATED FARMING AND ECOLOGICAL ENGINEERING

Welcome and review

- crop rotation, trap crop, intercrop;
- biofertilizers;
- the use of biocontrol agents, predators and parasites;
- biopesticides;
- botanical pesticides; and
- ecological engineering.

In this section, farmers will be asked the type of cropping pattern they have been practicing on their own farm. Sample questions will be as follows:

(a) The cropping patterns
(b) How long have you been practicing this?
(c) What are the advantages?
(d) What are the limitations?
(e) Do you have a plan to change this?

After getting their feedback, farmers should be educated the type of cropping pattern practiced by the farmers of other regions. A brief outline is given here. The detailed information can be obtained from the handbook.

The process of growing a number of crops on the same piece of land during the given period of time is termed as Intensive Cropping (Chandrasakaran, *et al.,* 2010). The methods involved in intensive cropping are as follows.

1. **Multiple cropping** is growing two or more crops on the same field in one year. Multiple cropping can be divided as (a) *sequential cropping,* (b) *relay cropping*, (c) *ratoon cropping or ratooning* and (d) *overlapping system of cropping*.
2. **Intercropping** is growing two or more crops simultaneously on the same field. Intercropping is termed as m*ixed intercropping* (*mixed cropping*) when two or more crops are grown simultaneously with no distinct row arrangement. It is called *row intercropping* (*intercropping*) when two or more crops are grown simultaneously where one or more crops are planted in rows.

The crop intensification is in both temporal and spatial dimensions. Types of intercropping are: (a) *parallel cropping*, (b) *companion cropping* and (c) *synergistic cropping*.

Principles of intercropping:

- The associating crop should be complimentary to the main crop.
- The subsidiary crop should be of shorter duration and of faster growing habits, to utilise early slow growing period of main crop.
- The component crops should require similar agronomic practices.
- Erect growing crops should be intercropped with cover crop.
- Erosion permitting crop should be intercropped with erosion resisting crop.
- The component crops should have different rooting pattern and depth of rooting.

Advantages of intercropping:

- It offers similar benefits to that from rotational cropping.
- The total biomass production/unit area/unit time is increased because of the fullest use of land as the inter row spaces are utilised which otherwise would have been used for weed growth.
- The fodder value in terms of quantity and quality becomes higher when a non-legume is intercropped with legume. *e.g.,* Napier + desmanthus, sorghum + cowpea.
- It provides crop yields in different times, which reduces the marketing risks.
- It offers more employment and better utilisation of labourers, machine and power throughout the year.
- It is an insurance against drought.

3. **Crop rotation**

Crop rotation may also be defined as a process of growing different crops in succession on a piece of land in a specific period of time with an object to get maximum profit from minimum investment without impairing the soil fertility.

Principles and advantages

If the same crop is repeatedly grown on the same land it is referred as *monoculture* or *monocropping* (*e.g.,* rice-rice-rice) whereas *crop rotation* is the repetitive cultivation of an orderly succession of different crops and crops and fallow on the same land. One cycle may take several years (one year or more than one year) to complete *e.g.,* rice-rice-pulse (one year), sugarcane–ratoon sugarcane–Rice (2 or 3 years), banana–ratoon banana–rice (3 years).

Advantages of crop rotation

- Crop rotation helps in maintaining of soil fertility, organic matter content and recycling of plant nutrients. All crops do not require the plant nutrients in the same proportion. If different crops are grown in rotation, the fertility of land is utilised more evenly and effectively.
- Restorative crops like heavy foliage crops and green manure crops included in rotation increase the nitrogen and organic matter content of the soil.
  Helps in control of specific weeds like bermuda grass, cyprus (sedges) and *Trianthema portulacastrum.*
- Avoids accumulation of toxins and maintains physical properties of soil.
- Controls certain soil borne pests and disease.
- Reduces the pressure of work due to different farm operations in a stipulated period of time.

After that their knowledge of farmers on the following areas should be explored by asking questions as mentioned in the previous modules.

(a) biofertilisers;
(b) biocontrol agents / natural enemies - predators and parasites of insect pests;
(c) botanical insecticides and how to make them; and
(d) the concept of ecological engineering.

Finally, each subtopic should be briefed to make farmers familiar with the terms and their use.

Biofertilizer: a broad term used for products containing living or dormant micro-organisms such as bacteria, fungi, actinomycetes and algae, alone or in combination, which on application help in fixing atmospheric nitrogen or solubilise/mobilise soil nutrients (FAO, 2019c). When applied to seeds, plant surfaces, or soil, colonise the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant (Vessey, 2003). The microorganisms in biofertilisers restore the soil's natural nutrient cycle and build soil organic matter. Through the use of biofertilisers, healthy plants can be grown, while enhancing the sustainability and the health of the soil. Biofertilisers can be expected to reduce the use of synthetic fertilisers and pesticides, but they are not yet able to replace their use. Some examples of biofertilisers are *Rhizobium*, *Azotobacter*, *Azospirilium* and blue green algae (BGA).

Rhizobium harzianum

For different pulses such as green gram, groundnut and chickpea, different strains of *Rhizobium harzianum* are produced. One pack is recommended to mix with 18 lb. (8.18 kg) of seed and 4 to 6 packages may be needed for one acre where the seed rate is about 108 lb. (49.1 kg) per acre.

Advantages of rhizobium inoculation

- Plants uptake more amount of nitrogen.
- Increase the root nodules of plant and fix atmospheric nitrogen to make available to the plants.
- The phosphobacteria converts the non-available form of phosphorus in the soil into available form to the plants.
- Helps for the better root development.
- The rhizobial treatment increases the yield.

Attention

- Enough care must be taken for rhizobial seed treatment that the seed coat should not be removed as it may reduce the seed germination.
- Always use freshly prepared Rhizobium packets.
- Fungicide seed treatment must be done 24 hrs earlier to Rhizobium seed treatment.
- Do not use Rhizobium packet if the content is dried.

***Trichoderma* spp.**

Treat the seeds with commercial formulation of *Trichoderma harzianum* or *T. viride* 10 g/kg seeds or mancozeb 3–4 g/kg seeds, and soil application of *Trichoderma* spp. 4 kg enriched in 250 kg FYM or 200 kg castor cake to prevent seed and soil borne diseases. However, *Trichoderma harzianum* was not recommended to use for chick pea in Sagaing region.

One bag of *T. viride* is sold at 1 000 MMK. It is recommended to use 60 bags per acre. However, ten bags can be mixed with two baskets of organic manure plus five pyis of bran and apply for one acre to reduce the cost.

Post-Harvest Aflatoxin Mitigation Strategies involve:

- If pod can be detached immediately after pulling the plants, they should be dried with solar bubble dryer rather than sun drying. As cold-storage at 20–22 °C can also reduce the aflatoxin formation in groundnut, medium enterprise owner should practice this method (DAR, 2019).
- Generally, aflatoxins are more concentrated in peanut seeds. Drying the pods to less than eight percent moisture content, removal of immature, discolored and damaged pods from the produce, not mixing the gleanings (leftover pods collected from the soil) with main produce and protection from storage insect pests. Immature pods should be removed from the haulms before feeding them to livestock.
- equipment sanitization; and
- separation of infected and healthy pods.

Biological control is defined here as the use of living organisms as control agents for pests, weeds and diseases. These control agents will be referred to as natural enemies. They feed on, compete with or otherwise inhibit pests and their population growth and spread.

They can be broadly categorised as follows:

- Invertebrate predators which feed in the larval or adult stage on invertebrate pests.
- Parasitic insects (parasitoids) which develop from eggs laid in or on the bodies of invertebrate pests, killing them in the micro-organisms, including viruses, bacteria, fungi and protozoa, which infect and debilitate or kill invertebrate pests, weedy plants or other micro-organisms.
- Herbivorous arthropods which consume and damage weedy plants in various stages.

Biological control involves the use of "natural enemies" as an essential component of IPM. In a broad sense, a natural enemy is an organism that causes the death or impairment of another organism. Biological control can be defined as using living natural enemies ("beneficial organisms") to control other living organisms ("pests"). International Standard for Phytosanitary Measures (ISPM) defines a biological control agent (BCA) as a "natural enemy, antagonist or competitor, or other organism, used for pest control".

Biological control can be used alone or in combination with other control methods in IPM programmes.

There are three main approaches to biological control:

1. Augmentation biological control –increasing the densities of native or non-native natural enemies with regular releases. Releases may be made
   - at the beginning of each season, when relatively few individuals of a natural enemy are released (these are expected to reproduce during a certain period), or
   - as a single mass release of a natural enemy expected to result in immediate control.
2. Conservation biological control – the manipulation of habitat with the aim of enhancing the reproduction, survival and efficacy of natural enemies already present in an affected area.
3. Classical biological control (CBC) – the introduction of a natural enemy of nonnative origin to control a pest, usually also non-native, with the aim of establishing a population of the natural enemy sufficient to achieve the sustainable control of the target pest.

Natural enemies involve predators and parasitoids. Detailed information can be available from the Handbook. The difference between predator, parasites and parasitoid is outlined here by Stehr (1975) as follows:

A predator is a free-living organism throughout its life: it kills its prey, is usually larger than its prey, and requires more than one prey to complete its development. Mantids, spiders, and many species of ladybird beetles are good examples of predators.

A parasite is an organism that is usually smaller than its host, and a single individual usually does not kill the host. Numerous individuals may irritate, weaken, or otherwise debilitate the host, and occasionally cause its death.

A parasitoid is a special kind of predator which is often about the same size as its host, kills its host, and required only one host (prey) for development into a free-living adult. Braconid wasps are good examples of parasitoids.

Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals. For example, canola oil and baking soda have pesticidal applications and are considered biopesticides. As of April 2016, there are 299 registered biopesticide active ingredients and 1401 active biopesticide product registrations (EPA - 2016).

They can be categorised (Lindberg and Arthurs, 2017) as follows:

(a) Biochemicals - derived from naturally occurring substances such as plant extracts. This includes insect repellants, insect attractants and repellants, pheromones, and non-pest management class—plant growth regulators, for example, Azadirachtin (broad-spectrum insecticide).
(b) Microbials **-** products containing micro-organisms or their fermentation by-products Examples
    - The bacterium *Bacillus thuringiensis* for use against caterpillars.
    - The fungus *Beauveria bassiana* for use against whiteflies, aphids and thrips.

Botanical Pesticides or natural **insecticides** are organic and natural **pesticides** that are derived from plants and minerals, that have naturally occurring defensive properties. Also, they have proven to be more useful than conventional **insecticides** as insects become more resistant to synthetic **pesticides**.

Ecological engineering, defined as the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both, has developed over the last 30 years, and rapidly over the last ten years. Its goals include the restoration of ecosystems that have been substantially disturbed by human activities and the development of new sustainable ecosystems that have both human and ecological values. It is especially needed as conventional energy sources diminish and amplification of nature's ecosystem services is needed even more (Mitsch, 2012)

SESSION VIII: FIELD DAY AND FIELD VISIT FOR KNOWLEDGE SHARING

Field observation and data recording

- special assignments;
- field day;
- field visit;
- farmer to farmer knowledge sharing;
- post training assessment; and
- lesson learned and step forward.

Field days and field visits: While the FFS works with a limited number of farmers, its experimentation field however, serves as a demonstration center for the entire community. Community farmers regularly visit the FFS field and discuss their problems with the FFS farmers. This sharing process is strengthened by organising regular field days and cross visits among farmers from different FFS communities at different suitable stages of crop growth. A field day is an occasion organised by FFS farmers and FFS Facilitators with the purpose to showcase all activities and achievements to other farmers in the community who did not participate in the FFS. This provides an opportunity for the scaling up operations in the future.

Considerations when planning a field day: Conduct a field day preferable when the crop has reached the maturity stage. Invite stakeholders, members of the farming community, policy makers, researchers and community leaders to view the plots and share in the experiences and observations of the FFS participants.

Objectives:

- observe and compare the farmer practice (FP), IPM plots or other trails;
- encourage other farmers to participate in future FFS;
- present results to financers of the FFS; and
- provide a forum for participants to show the skills developed and experiences learned.

Th following should be prepared for viewing by those attending:

- display of key AESA that represent changes in the crop during its growth;
- display of results of special experimentation;
- insect and/ or disease zoos used to facilitate learning about natural enemies, life cycles, damages etc.; and
- presentation of some of the team building and learning exercises.

Field day preparation

Description of the booths:

There are at least 7 booths in ICM-FFS field day. The following are the details of the booth activities (modified from Parul (2017):

1. ICM component booth:

a. nine colored stick surrounded by colored rope;
b. ICM Banner hanging in the behind;
c. establish ICM and FP plot at the front side of the booth;
d. a board describing points to increase rice yield;
e. a small board mentioning the booth no.;
f. ICM plot- Good quality rice seed in one pot; different chemical fertiliser; cow-manure; AWD pipe; dyke crop; a bird and its resting tree-branch;
light trap; hand-net; poison-bottle; spray-machine; rat trap; rice seedling; and
g. farmer's plot - to compare the ICM plot with farmer's plot, a balance needs to be set in between ICM and FP plot and keep more rice grain in ICM side and some money indicating more profit from ICM plot.

2. AESA booth:

a. nine colored stick surrounded by colored rope;
b. what is AESA and its objective in a poster;
c. one good poster with AESA done;
d. left over rice plant in the field with beneficial insects as harbor;
e. two insect zoo;
f. demonstration of beneficial and Harmful insects;
g. a poster with a poison bottle with red cross;
h. survey materials: Hand net, Water pan, etc.;
i. light trap; and
j. a small board mentioning the booth no.

3. Seed booth:

a. nine colored stick surrounded by colored rope;
b. one seed plot and one FP plot;

c. samples of seed and fertiliser used in front of the plots;
d. poster mentioning the characteristics of good seed;
e. poster mentioning the points of seed production;
f. demonstration of good seed; bad seed; seed sorting - hand and with water; germination test systems; ideal seedbed;
g. poster mentioning the special jobs done in seed plot;
h. seed threshing in writing;
i. seed storage: improved and farmers storage and poster of good storage; and
j. a small board mentioning the booth no.

4. Pest booth:

a. nine colored stick surrounded by colored rope;
b. line drawing of insect pests and diseases in the field;
c. line drawing of weeds and rodent in the field;
d. poster on the sign and symptoms of pests and diseases in the crops;
e. measures needs to be taken to manage the pests in the crops;
f. some specimens of pests collected from the field; and
g. a small board mentioning the booth no.

5. Predators and parasitoid booth:

a. nine colored stick surrounded by colored rope;
b. line drawing of natural enemies- predators and parasitoids in the field;
c. poster how pesticides adversely affect the natural enemies in the crops;
d. poster how to conserve the natural enemies in the crops;
e. some specimens of natural enemies collected from the field; and
f. a small board mentioning the booth no.

6. Pesticide booth:

a. nine colored stick surrounded by colored rope;
b. two model homestead: one with pesticide use in proper way and another in a wrong way;
c. line drawing how pesticides enters into human body;
d. poster on negative impacts of pesticides on environment;
e. measures needs to be taken during pesticides carrying, use and storing;

f. role play on wrong use of pesticides;
g. posters on measures needs to be taken before, during and after using pesticides;
h. some bottle of common pesticides; and
i. a small board mentioning the booth no.

7. Biopesticide and biofertiliser booth:

a. nine colored stick surrounded by colored rope;
b. line drawing how to make biopesticides and biofertilisers;
c. posters on advantages of biopesticides and biofertilisers;
d. some samples of biopesticides and biofertilizers;
e. some poster where biopesticides and biofertilisers are available; and
f. a small board mentioning the booth no.

FFS CURRICULUM

Week	Session#	Participatory discussion	Hands on practice
Pre-FFS		Inauguration of FFS; rice varieties, seed sorting, germination	(i) Identification and comparison of different seed varieties based on the crop, paddy, groundnut, sesame, green gram or chickpea
W-1	1	Introduction to FFS trials and select trials	(i) Seed soaking in salt water before sowing (this is only for paddy) (ii) Seedbed preparation and sowing
W-3	2	Nutrient management	(i) Identification of fertilisers (ii) Layout of trial plots
W-5	3	(i) Growth stage (ii) Urea application (LCC)	Transplanting ICM & other trial
W-7	4	Introduction to insecticide formulations (Granular, WDP, EC, etc.)	Insect zoo – collection of insects
W-8	5	Weed	(i) 1st weeding (ii) Weed identification
W-10	6	(i) AESA (ii) Insect (stem borer, leaf folder)	AESA-1
W-12	7	(i) IPM (ii) Insect (BPH)	(i) 2nd Weeding (ii) Roguing-1
W-14	8	(i) Rodents (ii) Plant diseases –bacterial blight	Searching for rodents, burrow and their damage in the filed Looking for plant diseases
W-17	9	(i) Insect: rice ear-bug (ii) Natural enemies (iii) False smut disease	Searching for insect pests, diseases and natural enemies in the filed
W-20	10	Bio-insecticides	Making neem seed kernel extract
Post FFS		Field day: and field visit	Sharing experiences and open discussion for lesson learned

The same principles will be applied for groundnut, sesame, green gram and chickpea with the modification of some cultural practices, insect pests and diseases depending on particular crop. For example, groundnut seeds will be impregnated with some fungicides or insecticides rather than soaking in salt water as carried out with paddy.

Agroecosystem analysis (AESA) toolkit

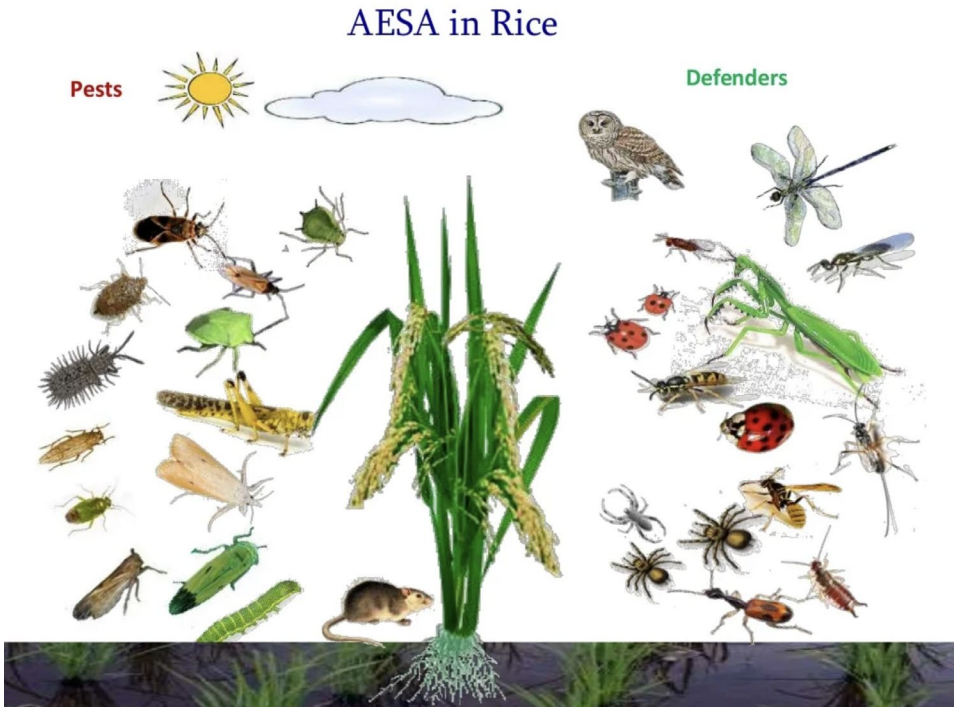
A. Activities

AESA activities from the brinjal by (Uniyal, 2015) can be as a model for some other crops paddy, such as groundnut, sesame, green gram and chick pea by making some modifications.

1. Farmers form groups of four to five each. Some groups take the Farmers Practice field and other groups take the IPM field.
2. Each group selects 20 sample hills across the diagonal of the field. To select a hill, walk across the diagonal of the field and choose a hill at every 5 m. In large fields increase the distance between selected plants.
3. Thoroughly observe insect pests on the leaves, on the stems and on the water surface. Record the number of each species.
4. Do the same observation for the natural enemies.
5. Count the total number of tillers per hill.
6. Observe the pests and natural enemies on the water surface and at the base of the plants.
7. Collect the predators in plastic vials to show to other groups.
8. Uproot one paddy plant for drawing.
9. After 20- hill observations are noted, find a place for the group to sit and make colour drawings on a large piece of paper. Draw the plant with the correct number of tillers. Draw the sun and indicate with clouds if it is cloudy. Plants infected with diseases or damaged leaves are coloured yellow. Draw the pests on the righthand side of the paddy plant as follows:
   Sucking pests:
   - defoliators
   - stem borers:
     - indicate total number found
     - indicate the total number of tillers.

     (- calculate the average per tiller)
10. After the drawing exercise, the following questions are discussed.
    a. Describe the general condition of the plant.
    b. What do farmers think to be the most important factors affecting their crops at this stage?
    c. What, if any, measure should be taken?

11. When all groups have finalised their drawings and answered the questions, they present their work to each other, explaining the sampling and drawings and discuss the answers to the three questions.
12. One group presents its results for each treatment.
13. Each week, a different group member makes the presentation. In Farmer Field Schools, the ecosystem analysis drawings of preceding weeks should be available for comparison and a discussion of the development of the crop and insect populations. It is easy to forget what the field looked like earlier in the season, what insect populations were found and when control measures were taken.



Source: Dr Sree

This picture will be changed with crop.

B. Group discussion and decision-making:
   - Each group will discuss the situation and make a recommendation.
   - A member of each group will now present the analysis in front of all participants. Make sure that a different person will present each week.
   - The facilitator will facilitate a discussion by asking guiding questions.
   - The facilitator also makes sure that all participants (also shy persons or illiterate persons) become actively involved in this process.
   - Formulate a common conclusion. The whole group should support the decision on what field management is required.
   - Make sure that the required activities (based on the decision) will be carried out.
   - Keep the drawing for comparison in the following weeks.

C. Some questions that can be used during the discussion:
   - Summarise the present situation of the field.
   - What aspect is the most important at this moment?
   - Is there a big change with last week?
   - Is there any serious pest or disease outbreak?
   - What is the situation of the beneficial insects?
   - Is there a balance in the field between pests and defenders?
   - Are you able to identify all pests and diseases?
   - Do you think the crop is healthy?
   - What management practices are needed at this moment?
   - When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.

- Are you expecting any problem to emerge during the next week? What problems? How can we avoid it? How can we be prepared?
- Summarise the actions to be take.

D. Presentation:
- Presentations made by member of each small group.
- Participants ask questions of presenter.
- Facilitator asks questions appropriate to analysis.
- Group discussion field conditions and agroecosystem relationship.
- "What if" scenarios discussed.
- Previous weeks agroecosystem drawing used for comparisons.
- Field management decisions critically examined by group.

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ISBN 978-92-5-136723-0
9 789251 367230
CC1306EN/1/09.22