STANDARD OPERATING PROCEDURES (SOP)

for

Integrated Pest Management (IPM)

सत्यमेव जयते

Government of India
Ministry of Agriculture
Department of Agriculture & Co-operation
Directorate of Plant Protection, Quarantine & Storage
N.H. IV, Faridabad (Haryana) 121 001

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Foreword

Agricultural production in India has increased considerably during the last four decades, leading to an era of food self-sufficiency. The remarkable growth has been achieved through the intervention of newer technologies in the form of high yielding crop varieties, chemical fertilizers and pesticides, as well as from the expansion of cropped area. At the same time, there is a rising public concern about the potential adverse effects of chemical pesticides on the human health, environment and biodiversity.

Pests are major biotic constraint to achieve self-sufficiency in ensuring food security. Losses due to pests in general, vary between 10-30% depending upon the genetic constituent of crop, its health and the governing environment. The pest vagaries are major impediment in achieving sustainable agricultural production. In view of injudicious use of chemical pesticides and environmental problems, Integrated Pest Management (IPM) has been accepted as a cardinal principle of Plant Protection in the overall Crop Protection Programme under the National Agricultural Policy of the Govt. of India. IPM being an eco-friendly and economically viable approach has been widely accepted all across the country. Human resource development, conservation & augmentation of bio-control agents, pests surveillance & monitoring, weed ecology and management and laboratory production of biological control agents are most important component of IPM to take proper decision to manage any pest problem.

With a view to provide technical knowledge to the staff of CIPMC located in different state, Standard Operating Procedure (SOP) covering different functional aspects of Integrated Pest Management is published by the Directorate of Plant Protection Quarantine and storage (DPPQS) in June 2014. The SOP has been developed with the technical inputs from experts from DPPQ & S, Faridabad. It will also be useful in reducing the pesticide residues in exportable agricultural commodities by managing pests/diseases/weeds/nematodes with least dependency on chemicals and promoting eco-friendly approaches and practices.

I am confident that this SOP will able to fulfill aspirations of our farmers to manage pest in their different crop ecosystems and facilitate agricultural extension officers to conduct Farmers Field School (FFS); orientation training (2 days), refresher training (5 days) and SLTP (long duration); surveillance and monitoring; laboratory mass multiplication; conservation and augmentation; weed ecology and management. I congratulate and thank all the members of CBG (Capacity Building Group) for IPM who has actively participated and provided inputs for compilation of this SOP.

Dr. S. N. Sushil
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PREFACE

Integrated Pest Management (IPM) has been accepted as a cardinal principal of Plant Protection in overall crop production programme under National Agricultural Policy of Government of India. This concept manages the pest population in such a manner that economic loss is avoided and adverse side effects of chemical pesticides on crops and environment is minimized. IPM being an eco-friendly, socially acceptable and economically viable approach has been widely accepted across the nation. Yet the penetration has not been felt at the grass root level. Efforts made in this direction suffer when officials responsible to run IPM related programmes are transferred because of unavoidable reasons. To overcome such constraints it was felt to come out with "STANDARD OPERATING PROCEDURE" (SOP) for IPM in this Directorate which can guide the fresh recruiter and/or transferred technical officials for implementing the IPM programmes successfully.

Consequently, a capacity building group on IPM was constituted by Plant Protection Adviser from the officials of the Directorate of Plant Protection, Quarantine and Storage to prepare and update the literature on IPM; refine & redefine the curriculum of various activities of Central IPM Centres of this Directorate scattered across the nation. Five different groups were formed to provide inputs on various aspects to contain pests/diseases/weeds/nematodes/rodents in crop ecosystems; breed bio-agents in labs and conserve natural enemies in the crop ecosystems and develop standard curriculum for HRD programmes.

It is believed that this SOP will help to cater to the needs of the new comer in the CIPMCs and will make him confident in promoting the IPM programme in the country.

June 5, 2014

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Contents

Chapter-I

Standardization of FFS Curriculum, HRD; Orientation Traning (2 days), Refresher training (5 days) and Season Long Training Programme (SLTP)

1. FARMERS FIELD SCHOOL FOR INTEGRATED PEST MANAGEMENT

Farmers Field School (FFS):

- Farmer Field Schools (FFS) is an agricultural school of farmer which is conducted by the farmers on their own fields. This is research based learning through non formal education(NFE)
- FFS provide opportunities for learning by doing. It teaches basic agricultural and pest management skills that make the farmers experts and perfect on their farms in decision makings.
- FFS is a forum where farmers and facilitators debate on observations, shows experiences and present new information to come to the conclusion

Aims of FFS

- Empowering farmers with knowledge and skills
- Making farmers experts in their own fields.
- Sharpening the farmers' ability to make critical and informed decisions.
- Sensitizing farmers in new ways of thinking and problem solving
- Helping farmers learning how to organize themselves and their communities to become sound socially and economically.

Essential elements of FFS:

The group:

- The group comprises of individuals (30 farmers) with common interests, forming the core of a Farmer Field School. The FFS tends to strengthen existing groups or may lead to the formation of new groups

The Field:

- The field is the school which has the facilities of training materials like plants, pests and natural enemies. In most cases, the groups provide a study site with a shaded area for follow-up discussions.

The Facilitator:

- The facicilitator is a technically competent person who leads group members through the hands-on exercise and facilitates the activities to arrive on conclusion.

FFS establishment

- Selection of right village for establishing FFS and the selection of right kind of farmers as trainees will greatly contribute to the success of the FFS. Prior to starting of FFS at least two visits are required.

First visit

- It is expected that the FFS facilitators will be establishing FFS in their own area of posting and hence they should be familiar with the villages profile based on the information that may have already, select potential villages for visiting.

Criteria and steps for village selection:

- All approachable location/villages should be selected
- With maximum pest problems should be selected
- High pesticide usage and related problems to be preferred
- Irrigation facilities should be preferred
- Too close to city to be avoided
- No IPM training conducted previously
- Political sensitiveness should be avoided
- Fairly easy access should be preferred
- Comfortable rapport between facilitators and farmers.
- Aware with the purpose of visit by the village leader
- Request him to invite all cotton/rice/vegetable growers (depending upon the crop chosen) for general meeting
- Collect village profile
- Area under crop cultivation
- Number of farmers
- Pest problems in previous crops
- Pesticide usage in previous crops
- Information about irrigation facilities
- Request the village head to organize meeting in the following week.
- Women farmers participation is also required
- The date, time should be fixed in consultation with village leader
- Social and economic status of the farmers

To identify potential farmers site selection during second visit:

- This visit should be one week prior to the first visit
- Organize the general meeting as planned
- Ensure participation from farmers, women farmers
- Discuss the important problems related to crop management
- Discuss about FFS structure
- Outline of FFS
- Nature of training
- No provision of honorarium for attending the FFS
- There will be refreshment in each session
- The facilitator should announce the interested farmers to work as farmer facilitator

Criteria and steps for farmer's selection:

- The farmers should be typical of that area in terms of crop cultivation
- Active farmers should be preferred
- Should be energetic and physically fit
- SC/ST /Women farmers should be given preference
- Willing to learn at their own.
- The village head will help in choosing right farmers.
- Finalize the list of 30 farmers.
- Request the selected farmers to attend the next meeting.
- Conduct this meeting at least two week before commencement of FFS
- Conduct signs and symptoms exercise
- Conduct meeting with selected farmers
- Hold participatory discussion to identify local problems related to total crop management
- Identify local needs
- Explain FFS activities in detail
- Discuss farmers practice
- Ask the farmers for their own practices to follow in farmers practice plot
- Explain the farmers about IPM practices are to be followed in the IPM plot
- With the consensus of the farmers, select suitable FFS field and training site
- Finalize the inaugural day for FFS and check out programme

Criteria and steps for field selection:

- Select minimum of 2 acres
- The field should be belonging to one farmer
- It should be easily accessible and should not be too far from FFS village
- The filed should be close to the meeting place (gathering place)
- Some shady areas should be nearer to the field
- No water stagnation in the field
- No abnormalities in the field
- Identify farmer who is willing to give the land for conducting field experiments and AESA
- He should agree to follow the schedule of farming operations as finalized by the farmers
- He should agree to meet all the expenditure involved for both the fields except the IPM inputs for pest management.
- He should agree to allow the farmer participant to work in that field to organize field day.
- At the planning meeting through participatory discussion with all selected farmers the facilitators should make verbal contract with FFS farmers.
- The FFS day of the week

- The time to start FFS session
- The duration of FFS sessions
- Norms/regulations/rules for FFS
- Grouping of participants
- Assign the name to each group
- Allow the participants to select the leader for their group
- Finalize the responsibilities of group leaders

Base line survey:

The base line survey should be conducted in FFS and Non FFS villages. All the 30 farmers and 10 non FFS farmers from the neighboring village should be interviewed. The survey should be completed immediately after the selection of FFS village and farmers and prior to conducting planning meeting.

Grouping of farmers:

At the beginning of the FFS, the trainees will be grouped into five small groups and the grouping will be maintained till the end of FFS. Each group will be named by the beneficial insects after discussion with the participants.

FFS gathering place:

The FFS will have a gathering place, close to the FFS field, where the farmers will be able to assemble, make drawing of their field observations, discuss and make presentations

- Close to the training field
- Accessible to road
- Provision for protection from sun and rain
- Sufficient arrangement to accommodate to all participants
- Select the site in concurrence with farmer participants.

FFS Duration:

The FFS should last for entire crop season. There will be a 14sessions during the period excluding FFS and field day.

FFS session and duration:

Each FFS session will last for 4 hours except for inaugural and field day. FFS shall run in the morning hours preferably.

Norms and expectations:

- The training norms should be set at the beginning of the FFS and clearly explained to the farmers.
- All FFS farmers should be punctual in attending FFS sessions
- The farmers should be committed and devoted to the work
- Attendance will be maintained in every session
- If any farmer remains absent for more than 25% of the FFS session, he should not be given certificate.
- No substitute should be allowed.

Facilitators:

- Should have good experience in hand to conducting FFS
- Should be punctual
- Should give due respect to the ideas of the participants
- Should be committed and devoted to the work
- He can use inputs of the group

Training methodologies:

- Season long
- Fully field oriented
- Learning material is field and it is mainly based on learning group
- Teaching science to farmers
- FFS should have minimum lecture and maximum interaction
- The basis for training approach is Non- formal
- Training curriculum is based on local needs
- FFS is characterized by free and open communication
- Working in small groups.

Objectives and quality indicators:

- Grow healthy crop
- Conserve natural enemies
- Observe field weekly
- Protect environment
- Make farmers expert in their own fields




FFS curriculum:

- Based on local needs and identified crop a general curriculum will be developed by the facilitators, prior to starting of the first FFS session. While developing the curriculum, the training objectives and quality indicators will be taken into consideration. The curriculum so developed at the beginning of the FFS will serve the guidelines for carrying out FFS activities. However, it should be remembered that changes in the curriculum topic/schedule of activities can be made depending upon the prevailing situation but this has to be done in consultation with FFS participant farmers.
- The training will focus on the four different areas as follows.

FFS curriculum and time matrix.

Item	% of time share of the activities and time matrix
Science and farmers	50%, 2hrs
Group dynamics and team building exercises	30%, 1hrs
Management aspects	10%, 30min
Organization aspects	10%, 30min

Science and farmers:

- AESA of different practices and trials
- Insect zoo
- Relevant special topics

Group dynamics/Team building/Ice breakers exercises; Organization and Management:

- Work plan
- Development
- Organizing field days
- Organizing FFS materials
- AESA follow up

All FFS session will have the following common activities

- Recapitulation of previous session activities
- Attendance of participatory farmers
- Presentation of day's activities
- Field visit for AESA
- AESA drawing, analysis of observation, discussion and decision making by sub-groups
- AESA presentation by group wise
- Follow up of AESA/field action
- Observation on experiments
- Insect zoo set up and observation
- Tea/ Refreshment break
- Group dynamics
- Special topics
- Planning for next week
- Review of days activities

KEY CONCEPTS AND TECHNIQUES USED IN FFS

Agro-Ecosystem Analysis:

This entails both living and non-living things found in an agro ecosystem and the environment. The activity helps in identifying the functions of the organisms found in the ecosystem and how they interact among each other.

Purposes of AESA:

- Promote learning by discovery and learner with their own analysis.
- Guide farmers to critically analyze and make better decision makers on their own fields.

Why AESA?

- It improves decision-making skills, through a field situation analysis by observing, all the biotic and abiotic drawing and discussion.

The following are to be noted while carrying out AESA:

General Parameters

- Group No.
- Field No.
- Date:
- Week No.
- General information
- Crop & Variety
- Date of planting./sowing
- Stage of the crop
- Spacing
- Fertilizer
- Weather
- Time of observation
- Plant population
- Germination %

Plant Parameters

- Number of hills/Number of plants
- Number of monopodiums/sympodia branches
- No. of leaves
- No. of diseased leaves
- No. of dead leaves
- Plant height
- No. of pods
- Treatment
- Treatment schedule
- Management practices
- Plant drawing
- Natural enemies
- Observations
- Soil moisture
- Diseases
- Insect pests
- Rodent damage./live burrows
- Plant health
- Deficiency
- Weeds
- parasites
- Predators
- Recommendations
- What management practices to be applied on crop production and protection aspects

Long term experiments and field studies:

The following field trials as participatory action research (PAR) may be adopted depending on the local needs of the farmers.

The learning cycle processes to be employed through facilitating scientific methods in choosing the problems for experimentation. All the experiments to be conducted with single variable factors only with three/four replications. Care to be taken to record observations properly and timely. The emphasis is to gain experience on skill experimentation so that the same can be repeated in future. The following long term experiments will enhance the decision making ability of the participants in terms of plant compensation ability like defoliation experiments, removal of fruiting bodies, detillering etc.

- Management practice trials
- Plant compensation studies
- Fertilizer trials
- Spacing trials
- Varietal trials
- Water management trials
- Any other need based trials
- While taking observations in these experiments more emphasis should be given on record of pest and natural enemies

Insect zoo studies:

Insect zoo studies in FFS helps in creating curiosity and interest among the participants and farmers. It creates conductive atmosphere for learning science in the field. Simple studies as functional role of the organism in the ecosystem, damage symptoms feeding potential and preference of predators, parasitization studies. This can be done using simple equipments such as plastic vials, containers, Petri plates, plastic cups and field cages etc.

Special topics:

Special topics support the AESA analysis involving more deeply on specific issues relating to ecosystem and IPM principles. Special topics sharpen the skill of the participants. It also provides training on basic experimentation methods. Special topics should be problem based and as per local needs and should be conducted in fields where the problems exist.

List of special topics may be chosen from the following depending on the crop and crop growth.

Example:

- Selection of healthy seeds
- Weed management
- Soil and nutrient management
- Water management
- Aphid management
- Thrips management
- Leaf folder management
- Stem borer management

- Not all plant injury will result in yield loss
- Case worm management.
- BPH management
- Leafhoppers management
- *Helicoverpa* management
- White fly management
- Pit fall traps
- Identification of natural enemies
- Post harvest technology
- Augmentation of *Trichogramma*
- Botanical pesticides
- NPB
- Bt
- Pheromone traps, light traps, bird perches
- Adverse effects of pesticides
- Diseases management
- Soil moisture and its role

- Soil characteristics
- Concept of agro-ecosystem
- Special topics on spiders
- Harvest and post harvest techniques
- Signs and symptoms of poisoning.
- Rodent management
- Safe use of pesticides

Non-Formal education/Facilitation activities:

On successful completion of the field the participants will conduct FFS and train farmers using NFE principles. Prime importance is to be given for NFE topics in the curriculum. The topics will help to strengthen farmers skills in facilitation, communication presentation and planning and to improve the individual contribution to the group.

Optimum utilization of available resources (NFE):

As all farmers are not supposed to be literate, therefore the method of facilitating the entire activities of FFS should be based on Non formal education (NFE). Farmers are from diverse groups in terms of socio-economic status, religion, caste, age, education, land holding, intelligence etc. Therefore, their participation should be facilitated in such a way so that they should understand that they are conducting serious FFS as per their requirements and skill. This will create their interest in the project.

Pre and Post Evaluation

In order to assess the level of IPM related knowledge before and after FFS and to know the impact of IPM training pre and post ballot box test are conducted

Ballot box test:

All ballot box tests to be conducted only in the fields.

Five categories for questions to be covered.

- Functional role of organism in ecosystem
- Feeding potential of crop defender and life cycle
- Damage symptoms
- Plant compensation ability
- Management aspects.

Comparison of pre and post training evaluation results show a significant gain in the score as a result of the training impact.

Reporting/ Documentation

The facilitators should keep the records properly. They should spend one day in a week for preparation of reports in the prescribed format to be sent to the headquarters weekly. Proper FFS records for all activities should be mentioned for IPM and non-IPM fields which will help to calculate cost: Benefit ratio.

Village:
Crop:
Crop stage:

- Raw data of all the observations made by the different group of farmers
- List of materials purchased and supplied to FFS farmers with their acknowledgements
- Important activities should be documented with photographs
- List of bio-control agent supplied to FFS farmers, with their signature
- List of technical literature supplied to FFS farmers, with their signature

FFS session Number	Date	AESA Decision FP	AESA decisions IPM practice	Special topics covered	Insect zoo studies covered	Topic on Non formal education covered	Number of farmers attended	Visitors record if any	Time matrix.	Other activities if any

Field day:

At the end of the season, the participants should organize field day in which local policy makers and farmers from neighboring villages are invited to the field site. The facilitators should remain in the background on this day as the participants run the programme. Certificates are awarded to the FFS participants. Format of the certificate is given in annexure.(in local language to be awarded to the farmer)

Other general guidelines:

- Farmers should be involved in planning for the FFS right from the beginning
- All activities should be truly participatory
- All efforts should be made to promote IPM through local media and inviting local leaders /progressive farmers to FFS
- Must try to arrange visits by students and teacher from local school to FFS

Post FFS activities:

The post FFS activities such as follow up visit by the farmers and to encourage farmers to start IPM clubs. After 4-6 visits the farmer participants should be encouraged to take up FFS activities which will help them to organize and continue FFS activities. Record keeping is an important activity. The facilitator should maintain one comprehensive record /register for each FFS. The record should contain the following.

- Village profile
- Farmer's participations
- Session wise activities carried out
- Attendance
- IPM kits supplied to farmers with their signatures.
- FFS inaugural day with photographs
- FFS field day with photographs
- Visitors information with their comments
- Name of state officers, scientists of SAU or KVK or any other technical experts involved
- List of honorarium paid to experts with topics delivered.
- Publicity obtained through media, copy to be pasted in the register.
- Post FFS activities and formation of Self help groups.
- FFS record register having farmers attendance should be countersigned by the village sarpanch/ADO of that area.

2. ORIENTATION TRAINING PROGRAMME ON FARMERS FIELD SCHOOL

Background:

The Farmer Field School (FFS) is farmer education based, lasts for the 14 session and targets a group consisting of 30 farmers. The FFS consists of informal activities, which are hands-on and oriented towards improved decision making.

FFS will have a better impact when it is well planned:

Orientation programme on FFS will meet to the following objectives:

- Improvement in the knowledge on AESA
- Improvement in the knowledge on special topics
- Improvement in the knowledge on preparation of session guides/technical literature.
- Improvement in the knowledge on facilitation skills
- Improvement in the knowledge on skill in identification of insect pest, natural enemies and disease symptoms
- Improvement in the knowledge on Non-Formal education.
- To create confidence among facilitators to make the farmers self decision makers.

Goal of Farmers Field School:

- FFS training programmes are a process in which IPM becomes owned by farmers. They don't convince farmers to adopt IPM, farmers convince themselves.
- FFS as a corner stone of sustainable agriculture seeks to improve farmer practices in order to create higher profits while improving environment quality and community health.

Orientation training programme for facilitators for conducting FFS:

Days	Time	Activities
Day 1	08.30-09.00	Registration
	09.00-10.00	Inauguration
	10.00-11.00	Concept of AESA-Field exercise
	11.00-11.15	Tea break
	11.15-11.45	Pre-evaluation test
	11.45-13.00	Drawing, presentation and discussion on AESA by groups
	13.00-14.00	Lunch break
	14.00-14.30	Team building exercise
	14.30-15.30	Insect zoo activities-Field exercises
	15.30-16.30	Adverse effects of pesticides-Field demonstration
	16.30-17.30	Use of traps
	17.30-17.45	Review of days activities
Day 2	08.30-08.45	Briefing of days activities
	08.45-10.45	Collection of major (identified) pest of all stages and damage symptoms, collection of, natural enemies for the pest identified. Collection of diseases specimens
	10.45-11.00	Tea break
	11.00-11.30	Presentation and discussion on special topic
	11.30-12.30	Concept of Farmers field school Key factors for village selection, potential farmers site selection, discussion on bench mark surveys
	12.30-13.00	Discussion on Par experiments
	13.00-14.00	Lunch break
	14.00-14.30	Use of traps, preparation of session guides for FFS discussion
	14.30-15.00	Identification of symptoms of diseases
	15.00-16.00	FFS curriculum development by the facilitators choosing model crop
	16.00-16.15	Tea break
	16.15-17.15	Presentation and discussion on curriculum development
	17.15-17.30	Review of days activities
	17.30-17.45	Concluding remarks.

3. FACILITATORS GUIDE FOR SEASON LONG TRAINING PROGRAMME (SLTP)

Introduction:

Green revolution has made India a country of food scarcity to the country of food surplus and provided food security to the nation. But it has made farmers heavily to depend on chemical pesticide for crop protection. The chemical control of agricultural pests has dominated the scene, but its overuse has led to adverse effects on farm budgets, human health and the environment, as well as on international trade. New pest problems continue to develop. Integrated pest management, which combines biological control, host plant resistance and appropriate farming practices, and minimizes the use of pesticides, is the best option for the future, as it guarantees yields, reduces costs, environmentally friendly and contributes to the sustainability of agriculture. The need for sustainable agriculture is not pesticides but Integrated Pest Management. Hence Government of India has adopted IPM as its crop protection policy for the country.

Integrated Pest Management:

Integrated Pest Management means a pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible, and maintains the pest populations at levels below those causing economically unacceptable damage or loss.

Definition:

IPM is a knowledge-intensive and farmer-based management approach that encourages natural control of pest populations by anticipating pest problems and preventing pests from reaching economically damaging levels. All appropriate techniques are used such as enhancing natural enemies, planting pest-resistant crops, adapting cultural management, and, as a last resort, using pesticides judiciously

Promotion of IPM-Government Policy:

Government of India has initiated a number of positive steps for promotion of IPM in our country.

- Establishment of Central IPM Centers
- Registration of Bio-Pesticides
- Human resource Development on IPM through SLTP
- Farmers Field School

Objectives of SLTP:

- To create more trained man power to State Government for imparting IPM training programme.
- To give up the attitude of over dependence on chemical pesticides
- To change knowledge, attitude and practice of crop protection functionaries for better management practices
- To use the modality of FFS as a learning tool for pest management.
- To create confidence to participants to solve field problems faced by the farmers
- To orient the participants knowledge, attitude and practice towards IPM
- To work in group co-hesion
- To provide opportunity to learn through discovery
- To find solution to problems through Participatory Action Research(PAR)
- To understand the concept of AESA as decision making process
- To motivate and to establish IPM clubs in FFS villages

Approaches- SLTP:

- Field oriented
- Creates confidence to trainees to face field problems

Components of SLTP:

- Funds
- Facilitators
- Supporting staff
- Participants
- Field guide
- Training facilities

Funds:

Funds are essential to conduct season long training programme on IPM. To conduct 30 days SLTP involving 30 participants plus 7 resource persons and four supporting staff a reasonable fund is required.

Items of expenditure:

- Arrangement for inauguration
- Accommodation arrangements for facilitators, participants and supporting staff
- Honorarium for facilitators and supporting staff
- Training materials (IPM kit) for participants
- Training materials for field exercises
- Field materials
- Stationery
- Transport arrangements

- POL
- Communication expenses
- Medical expenditure
- Honorarium for experts from outside
- Arrangements for field day
- Valedictory
- Miscellaneous expenses

General co-coordinator:

The training programme should have general co-ordinator who is responsible for training expenditure and maintain the accounts for submission to HQ. The general coordinator should spend as per financial guidelines provided and periodically monitor the accounts to not exceed the limit of sanctioned budget.

Resource persons & Supporting staff:

The trainers are known as resource persons or facilitators and trainees as participants.

Role of Resource persons:

Resource persons provide facilities needed for training. He plays the role of friend, facilitator, catalyst, educator, communicator, listener, organizer, and motivator. The selected person should have adequate IPM field experience and have undergone previous SLTP training programme. The resource persons are assigned to groups (numbering five to six)as per number of groups formed during the training programme.

The floating resource persons are specialists temporarily drawn to deal special topics, panel discussion etc. They should be from ICAR, SAU, State Department, research institutes, NGOs etc.

Supporting staff:

There should be minimum of four supporting staff. (Including drivers) They should support general coordinator to assist in day to day purchases, maintenance of accounts, preparation of reports and communication works etc.

Participants:

The ideal strength for SLTP is 30 participants.PPA/APPA (IPM) will approve the nomination of 30 participants. The General coordinator before commencement of the training should obtain nomination letter from their controlling officer and he should submit his personal profile with contact address

If participants from different states, grouping should be done mixing all with at least one member of host state in each group. 30 participants can be grouped into five groups for providing good facilities. Each group should be called in the name of beneficial insect. Each group should select a leader and the group should remain throughout the training programme and should work as a team.

Syllabus and field guide:

The National IPM leader should arrange curriculum development committee at least one month before the training programme. The members of the training programme should be General Co-ordinator, Technical Co-ordinator, two technical experts. Two scientists from SAU /ICAR
While framing the curriculum the committee should take into accounts the principles of IPM

- Training Facilities: essential elements required for conducting SLTP
- Office room
- Accommodation for resource persons and supporting staff
- Arrangements for food and refreshment
- Class room facilities
- Transport
- Training site
- Fields for conducting exercises
- FFS villages
- Recreation room for participants
- Medical facilities
- Support from Department/SAU/ICAR

Office room:

It is just like training control room, should have the facilities such as telephone, computer, Xerox machine, place to keep IPM kits, stationery and training materials for field exercise. The general coordinator should have an administrative staff to look after the general administration and maintain accounts pertaining to the training.

Accommodation:

Good accommodation should be provided to all participants and resource persons involved. All resource persons along with participants should stay in the training venue itself.
Arrangement for food and refreshment:

The general coordinator should appoint food committee, where the participants must prepare menu within the sanctioned budget and food and refreshments should be supplied to the participant's resource persons and supporting staff, visitors etc. Deficiencies in not supplying timely may upset the training atmosphere.

Class room facilities:

Class room facilities are required for participants to assemble, analyze, discuss and present the data collected from fields. The class

room facilities may also be used for panel discussion and to have discussion with experts. Normally it should be carried out during afternoon hours. Rooms should have minimum of 45 chairs, writing and display boards, slide projector, OHP and other training materials like drawing paper, sketch pens, cello tape, markers etc.

Transport:

At least two mini buses and one Jeep are required for the participants and resource persons are needed to meet the transport requirements. The transport is required to visit FFS villages, study tours, field visits and to provide transport to floating resource persons. Regular vehicle with drivers may be drawn from Central IPM centers and from Department of Agriculture (Host state)

Training site:

Training site should have at least five acres with different stages of crop growth.

FFS villages:

Since participants are divided into five groups, five nearby villages should be selected for conducting practice FFS sessions.30 farmers from each village are to be identified. They will assemble on a specific day during morning hours to conduct FFS sessions. Field day is conducted during last day of the session.FFS farmers are subsequently encouraged to form IPM clubs to promote IPM.

Recreation room:

Since training site is normally away from town participants and resource persons need recreation after training hours. A separate room may be provided to play indoor games and to make newspaper/magazines available with TV facilities. The resource persons and facilitating group members can meet and plant for the next day activities.

Medical facilities:

First aid boxes should be made available to the training site. Essential common medicines for cold fever, dysentery, diarrhea, headache, body pain may be stored in office room may be given to participants as and when need arises.

Support for SAU/ICAR/ARS:

It is better to select training site from ARS/SAU/ICAR institutes. This will have facilities for accommodation, experimental fields also scientists for panel discussion.

SLTP field guide:

The curriculum should be based on the principles of IPM while drafting the training curriculum before the commencement of the training based on the principles of IPM.

Principles of IPM:

Integrated Pest Management (IPM) for sustainable agriculture seeks to improve farmer practices in order to create higher profits while improving environment quality and community health. In order to do this IPM implementation is based on four practical principles:

- Grow a healthy crop
- Conserve natural enemies
- Observe field regularly.
- Farmers become experts

These principles describe the main actions of IPM implementation. Specific processes that take into consideration the variation of each field and farm family backup each principle, so that decision making process will be done on a field-by-field, season-by-season basis. Each principle is described below:

Grow a Healthy Crop means using varieties resistant to major pests and diseases but well adapted to the local environment. The principle also includes using proper fertilizers (chemical and organic), irrigation, and soil management which are critical for a healthy plant. A healthy crop can resist diseases and compensate for damage caused by diseases and insects so that plant injury does not always lead to yield-losses. A robust healthy crop is the first step in IPM methods, and foundation for an optimal yield.

Conserve Natural Enemies. In all agricultural ecosystems, there are predators (e.g. insects, spiders, frogs, etc.), parasites and diseases which attack eggs, larvae, nymphs, pupae, and adult stages of insect pests. These "natural enemies" occur naturally in all fields, orchards and vegetable fields. They biologically control most insect pests most of the time. Learning to recognize and manage these natural enemies is one major focus of IPM training so that they are not destroyed by unnecessary applications of herbicides, insecticides and

fungicides but are allowed to work for the farmer's benefit.

Conserve natural enemies:

Observe Fields regularly is necessary to assess crop development, diseases, weeds, rats, and Insect pest populations. In most cases, an experienced IPM farmer does this observation during a short time (usually less than a few minutes per field) while carrying out other crop maintenance activities (irrigation, etc.). Observations should determine how the crop is growing and if there are pests or usually present and sufficient to keep pests at low numbers. Weather conditions, soil nitrogen levels, and degree of host plant resistance will determine if diseases will subside or become more serious. In the case of rats, community level dynamics determine rat infestations and control programs. IPM Farmers must be knowledgeable of these factors to properly and economically manage crops. In some cases natural enemies, plant resistance and plant compensation cannot prevent yield-losses due to weeds, rats, insects, or diseases. Proper assessments must be made to effectively and profitably manage the use of inputs such as labor, quality seed, resistant varieties, fertilizers, drainage systems, community organizing and pesticides in order to ensure profitable production. Observation skills and decision making are key to becoming an expert IPM farmer and require field level practice for most farmers and extension staff.

Farmers Become Experts is necessary for a modern agriculture in which farmers are responsible for farm level management. Future gains in yields, profits, and sustainability will be the result of farmers making better use of available and new technologies and limited resources. More emphasis in all agriculture programs must be placed on the ability of farmers to make better decisions, increase their own efficiency, and become better managers. The future of food production and food security will depend on how well farmers can innovate and manage systems. IPM is implemented by farmers and thus requires an emphasis on farmers' skills and knowledge.

Basic Concepts and Assumptions:

- IPM is not a "packaged technology" that is "adopted" by farmers. IPM is a process of decision making and farming which is gradually improved with greater ecological knowledge, and observation skills.
- IPM skills and concepts are best learned, practiced, and debated in the field. The field is the best teacher. Stay away from energy intensive multi-media lecture halls.
- Season-long training courses allow all plant, insect, disease, and weed development processes and management to be observed and validated over time. IPM training must be carried out over all crop stages.
- Farmers must be allowed to actively participate and share their experiences during training to achieve maximum interest and effectiveness. Local or indigenous knowledge of the environment, varieties, pests, etc. must play a major role during decision making.
- Trainers must not lecture, but should facilitate a process of learning. Trainers do not convince farmers, but rather provide structured experiences so farmers can test IPM methods and convince themselves about which are useful and which are not.
- The content of IPM training programs for extension staff and farmers are not limited to the traditional "plant protection methods" (e.g. mechanical, biological, cultural, mechanical, and ETLs) but also includes the following:


Crop development and physiology

Agronomic methods for a healthy crop


Varietal impact for maximum yield Soil fertility management for higher yields


Minimize Pest insect and damage impact Conserve natural enemies

Helps to develop Observation skills

Helps to focus on environmental issues to understand managerial skills

Economic threshold Level & AESA:

- Economic threshold levels (ETLs) are not used for field level decision making throughout most of this Facilitator's Guide. The ETLs are replaced with the Agro- Ecosystem Analysis methods that integrate more decision making parameters. The reason for moving away from ETLs perhaps should be explained here since most IPM programs are based at least to some degree on ETLs.
- The first and greatest problem of ETLs is the variability of parameters used for ETL computation. The three main parameters of the ETL are management costs (Rs/ha), the commodity price (Rs/kg), and the damage coefficient which is the rate of yield loss per damaging factor (e.g. kg/ha loss per degree of soil drought, or kg/ha loss per density of insects no. /hill). Management costs depend on the type of compounds used (cheap or expensive), access to tools (owned or rented), labor costs (own or hired), differences between regions (near cities or far from cities), and many other conditions. Commodity prices are stable in some areas for crops, but prices for many crops often fluctuate depending on local markets. Finally, the damage coefficient will vary according to the variety, water availability, weeds in the field, nutrient levels, weather, farmer competence in growing the crop, disease infection, stage of the plant, plant spacing, etc. More important is that not all injury leads to yield loss. In the case of over-compensation displayed by some crops (e.g. cotton), some injury actually leads to an increase in yields. In the almost all cases, published ETLs do not apply to the field situation at hand. The computed ETL applies only

Developing an IPM training program requires several steps in order to build the necessary scientific knowledge, cadre of trainers. The national seasonal long training programs have found that the following steps are essential for IPM training to move from a "good idea" to an established national IPM training programme.

Step 1. Curriculum setting
Step 2. Arrangement for Core Trainer-Facilitators
Step 3. Carry-out Season-Long Training of IPM Trainers
Step 4. Implement Farmer Field Schools
Step 5. Develop follow-up activities

***Training of IPM Trainers**:*

It is assumed that recruits for Core IPM trainers already are proficient in growing crops from land preparation to harvest. It is also assumed that they have a good knowledge of the crop ecosystem and are comfortable with working full-time in the field. The Core IPM Trainer's course will focus on those

I. Course content

- Training management of SLTP for IPM Field Trainers
- Leadership skills
- Non-formal adult education skills
- Work plan, and proposal development skills
- Problem solving and supervision skills

II. Duration

The refresher Training Course is typically 5 days in length and can directly precede the SLTP for 30 days duration.

The refresher training program should carry out basic activities on non-formal adult education methods and theory, leadership methods and theory, and management methods (work plan development) (Curriculum for refresher training course enclosed).

The training program should also review the curriculum for the season-long training based on local need, crop and field situations.

Season-Long Training of IPM Field Trainers:

The Season-Long Training of IPM Field Trainers is the basic course required for field trainers to become proficient in growing a crop, in implementing IPM, and in learning how to implement IPM training through the Farmer Field School model. The season-long duration of the program is to insure that all crop stages are studied and all management decisions are seen through to their economic ends

Objectives:

- By the end of the course, the trainers will be able to:
- Grow a healthy crop
- Make effective plant protection field decisions dealing with insect and disease pests, rats, weeds, birds, and snails (where appropriate) while considering local ecological, social and economic situations.
- Solve new problems presented in the field.
- Initiate training farmers using the Farmer Field School education model

Rational for Season-long Training.

- The season-long nature of training is required for several scientific and social factors including;
- Pest problems are specific to each stage of crop so training should be carried out over all stages of the crop.
- Population dynamics, disease epidemics, plant compensation, and crop development are processes completely.
- The outcome of management decisions made during one crop stage is observable only at another later crop stage, and most often at harvest (e.g. profitability, yield and yield components).
- Extension workers are often isolated from scientific and social advisors and therefore must be able to solve most problems without outside assistance. Longer field based training provides these skills

Training methodology:

Training methodology is adopted to implement the syllabus is participatory training methods. It is learning by doing on the line of Non-Formal education. Hence participants feel to express themselves, involve actively and have higher motivation. Participatory approach gives priority on experiences sharing, on farm experimentation and exercise, case studies, role play, brain storming, group dynamics, group discussion, assignments, panel discussion etc. Field exercises on SLTP should be arranged on participatory training method. Field exercise guide for the specific crop should be on the model of field guide of discovery based exercises for rice IPM as given below.

Significant activities of SLTP

Crop Physiology:

Studies of crop physiology: when a crop attains different stages, pests and diseases occurrence also vary. Hence the participants should have through knowledge on morphology and physiology of

different stages of the crop like seedling, vegetative, flowering, pod formation and grain maturity stages. Participants should collect plants from each stage and study plant characteristics viz plant height, number of branches, leaves, flowers and fruits, influence of a biotic and biotic factor on plants. Plant compensation ability, management practices to overcome adverse a biotic and biotic factors. Before commencement of the training arrangement should be made In the training site to have different stages of crop growth so that the participants can study all stages of the crop within the training period.

Agro ecosystem analysis:

It is a field exercises mainly used as a tool to educate the participants/farmers to analyze the field situation and make a decision about actions required in the field. It is a group exercise having set of rules and is carried out under the guidance of resource persons.. It consists of four stages. Field observation, analysis of observation data, drawing and presentation. Participants/farmers groups have to carry out AESA every prescribed day in a week and in their drawing charts should make recommendations for implementation during the week. It is a vital exercise to make participants/farmers experts in the field on decision making process.

Special topics:

To deal the topics such as water, weed nutrient management, management of soil and disease management. Special topics should focus on major pest, symptoms of their damage, management practices, insect ecology; pesticide poisoning, adverse effects of pesticides etc may be discussed. The topics are also given.

Participatory Action Research:

This exercise involves participants in studying field problems and finding solutions to them. It is primary learning strategy for empowering participants and only secondary as producing results. It is mainly used as collective investigation to initiate community actions on solving local problems. It is normally a season long exercise with weekly observation and decision making. The models for PAR are also given. Varietal impact, IPM vs. Non-IPM, simulation studies, water management and Nutrient management etc. PAR encourages participants/farmers to play a central role to find solutions to their field problems.

Non formal education:

NFE is an activity or force which works to achieve common goal of the group. Each group has a leader and takes a collective decision. Once collective decision is made, then execution is the responsibility of all members of the group. The leader must accord due recognition to all members in achieving the group's goal. He should not take credit for himself. It is a team building exercise from which group members learn how to work together and contribute for the success of the group. It creates healthy competition between the groups and motivates for high involvement. The group dynamics should provide enjoyment to the participants by breaking the monotony and to come out with desired results. The example of group dynamics are water brigade, tower building message relay nine dot game, no lifting of pen etc.

Farmers Field School Activities (FFS practice session):

SLTP has in build provision to conduct FFS simultaneously. This provides opportunity to participants to understand field based learning experiences involving the farmers, the need to transfer IPM skills immediately to the farmer and to conduct FFS after SLTP

During SLTP five participants groups are conducting FFS on the crop selected for IPM training. Hence organizer should select a training time when SLTP site and FFS villages have the crop selected for the training. Normally whatever participants learnt in SLTP during the week period in on the basis for preparation of lesson plan for conducting FFS in the week or participants can make file visits to FFS village one or two days in advance, observe crop condition and prepare lesson Plan for FFSs A model FFS curriculum is developed and enclosed. Each group visits the village on a particular day in a week, meets 30 selected farmers and conduct FFS session. A set of activities to be carried out during FFS sessions are also given. FFS farmers should undergo pre and post evaluation tests. The main aim is to introduce IPM concepts and principles. FFS farmers should be encouraged to form IPM clubs to continue IPM activities.

Course evaluation:

SLTP needs periodic evaluation to assess the training impact. Evaluation activities strengthen training design and increase feeling of ownership. Pre and post evaluation are carried out through ballot box test methods. Mid –term evaluation is carried out by written test in the middle of the training programme. Daily evaluation is done by

itemized response technique i.e. Inviting opinions of participants about the training activities and listing out good things and for wrong things for improvement needed on the day and suggestions for improvement. Resource persons should take immediate steps to act on suggestion on improvements. Such feedback provides information about learning and feelings of participants to the resource persons who can re-orient the training activities to the extent possible in response to feed back.

Activities for SLTP in detail

Course Activities:

The objectives are met through intensive study. There are season-long field activities which provide plant protection concepts, crop production skills, and Farmer Field School training skills. There are also topic specific activities that are completed in a two to four hour sessions. All topics are learned through experiential hands-on activities, allowing for maximum learning to take place. The methods are designed to build on the current level of experience, knowledge and skills of the trainees. The TOT participants are divided into teams of 4-6 participants. The inter-related training components in the Training of IPM Field Trainers field course include the following:

Season-long Field Studies carried out by trainees:

- **IPM vs. Farmer Practice** Comparison (to be carried out by all training groups). All field work carried out by trainers including production, data collection, data analysis, and report writing.
- **Classical IPM Field Studies** (2-4 studies per training group). All field work is carried out by trainees including production, data collection, data analysis, and report writing.

Examples of Field Study titles:

Nitrogen efficiency and impact on pests

P or K response and impact on pests

Variety evaluation and impact on pests

De-tillering plant compensation simulation

Defoliator plant compensation simulation

No spray on susceptible and resistant varieties

Weed management comparisons

Collection of natural enemies, disease, insect pest

Topic Specific "Field Guide Activities" are carried out in the field or open room and focus on the following IPM skill and concept areas:

- Stage specific plant physiology and plant compensation
- Diseases and epidemiology
- Weeds
- Insect pests, detritivors, and natural enemies
- Ecosystem management (sampling, decision making)
- Agricultural poisons
- Health and environment issues
- Group dynamics, Non-formal education
- Management Skills (work plans and leadership)

Non-Formal Adult Education Methods & Processes:

During the SLTP trainees will learn about NFE methods and processes and group dynamics. They will develop skills to act as a facilitator during farmers' training in which farmers will discover through experiential learning ecological relations in the crop ecosystem.

Management skills*:*

Trainees will also learn other skills, e.g. budgeting, necessary to conduct and organize FFS in their own districts.

Special topics:

Delivered by experts on specific topics. These topics should cover specific areas of interest to IPM including technical and social aspects. The involvement of NGO's, universities, researchers, and others during this time provides the participants with exposure to numerous resource persons and topics of local value and not already included in the course materials.

Farmer Field School (FFS):

Planning should be carried out during the SLTP period. Planning includes decisions on how participants will be chosen, where the FFS study field will be situated, time of implementation, weekly topics, , opening ceremony, Field Days, certificates for farmers, and other aspects of making an implementation plan to be approved by local state officials ,University etc)

A "Field Day" should be organized at the end of the SLTP for participants to present the result of field studies, field guide activities, and FFS planning. The goal of the Field Day is to ensure that participants will be able to implement IPM programs in their area. The success of the training programme is determined by the participants work after the SLTP

Training/Facilitation Team:

The Season-Long training programme should be carried out by a Training/Facilitation Team in addition to the support staff necessary for training logistics. The Team should have one or two trainers with experience in running Season-Long IPM training, have extensive experience in the field as well as in running the day to day management of a SLTP

While Senior Trainers manage the SLTP implementation, the Facilitator/Training team will carry out day to day supervision and teaching of the participants. The team members should have already participated in the Core Trainers Training and have practical field skills since they will be in the field with participants on a daily basis. A ratio of 1 trainer to 5 participants is desired.

This team should be at the SLTP site one week before the training to make preparations. This team should also meet daily to prepare for training, and make a daily evaluation of the program. During actual training, the senior trainer can lead many activities, but it is preferable if the trainers share in this responsibility until participants can take over some of the training activities

The Training Team should maintain open communication with participants with frequent formal and in-formal evaluations/discussion on the progress of trainings.

Weekly Training Programme:

Each morning, the teams will spend time in their Field Studies to take care of the field (irrigation, weeding, fertilization, pest management, etc.), and collect data for the Field Study implementation.

No.	Day	Activities
1	Monday	Crop physiology Agronomy
2	Tuesday	Agro ecosystem analysis field observation, presentation and discussion, Non formal education
3	Wednesday	Participatory action research, Special topics, Non formal education
4	Thursday	Insect pests, natural enemies, panel discussion
5	Friday	Farmers field school and feedback from FFS
6	Saturday	Field visit and review of weeks activities

Study fields:

- Study Fields with a total area of about 5 Ac for 40 trainees will be needed for field work during the training. The fields should be close (walking distance) to the training site.
- Pre-SLTP Preparations
- There are numerous pre-TOT preparations that must be done 2 to 3 weeks prior to the course initiation. Usually this will require one or more SLTP trainers to be on site before the training begins.
- Field Preparation should be done beginning 2-3 weeks before the beginning of the SLTP. If the trainees are too learn how to prepare land, and then set aside a small area for experience. However, to save time the fields should be ready for layout of field studies and planting before the SLTP begins.
- Materials for training should be listed and bought before training. Seed, fertilizer, manures, field signs and labels, etc. should be ready on the first day of training. Other training materials such as paper, markers, name tags, hats, shirts, etc. should also be purchased beforehand.
- Logistics such as transportation, sleeping arrangements, meals, bathing, clothes washing, telephone/mail service, newspapers, recreation (football, badminton, TV, video), religious services, etc. should be considered before trainees arrive.
- A pre-test (field based ballot box style, and/or written exam) should be prepared to test trainees during the first days of the SLTP. The pre-test should be field based to test recognition of insect pests, diseases, weeds, natural enemies, damage, etc. as well as problem solving. A written pre-test could also be given to test basic knowledge on life cycles, pesticides, health and environmental issues. The pre-test should be repeated at the end of the course to help evaluate the effectiveness of the training.

Resource Persons:

- Resource persons are non-resident trainers and other experts that can provide practical inputs to the SLTP. Typically, researchers, university professors, international visitors, NGOs, and others can provide some refreshing input to the season-long training. However, it is important to provide some tips to these resource persons
- Go to the field together for field walks where questions and answers can take place.
- Leave slides and lectures until after field interactions.
- Request the resource person to be as "participatory" as possible.
- Be sure that the resource person gives an address and other contact information for future reference by trainees.

Farmers' Field Schools (FFS) (Practice FFS sessions):

The SLTP is designed to prepare participants to become trainers in FFS is to be organized during the SLTP course, 5 FFS should be organized in communities nearby the SLTP site. Villages and farmer groups will need to be identified before the start of the training. The fields used in the training (about 1000 m2) should be of same crop age around the same time as the training will start.

One team of participants is responsible for conducting one FFS. A FFS usually consists of about 25 farmers, which will also work in groups of 4-6 persons during the FFS. The FFS will run in the morning once in a week. The trainers will be able to use experiences gained and exercises carried out during the previous week with a farmers' group. The programme for the FFS will be planned every week together with the trainers. Ecosystem analysis will be done every week by the farmers. Special topics will be carried out as well every session. Snacks should be served.

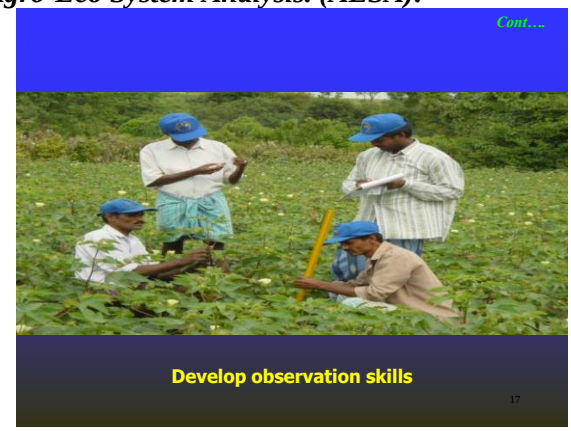
At the end of a FFS, a "Field Day" will be organized to present the results of the FFS, other farmers, agricultural staff, and local government officials in the community.

Farmer Field School Objectives:

- Describe the development of the crop.
- Describe plant compensation and give an example of the importance of plant compensation
- Identify the ecological function, life-cycle and give the local name of major insect detritions, insect pests and natural enemies seen in the rice field.
- Identify the local name and development factors of major diseases found causing yield losses in the field (if they exist).
- Identify rat damage and rat habitat where appropriate
- Describe the toxicity of commonly used pesticides (herbicides, fungicides, insecticides, rodenticides, and molluscicides) and methods to avoid exposure to pesticides.
- Describe the effect of pesticides (herbicides, fungicides, insecticides, rodenticides, and molluscicides) on target pests, natural enemies, non-target pests, the environment and health of farmers and consumers.
- Describe the level of potential yield-loss given a particular field condition and compare with the cost of controlling yield-loss factors (decision making).
- Describe the potential development of pests in the field given the field conditions (plant development and stage, weather pattern, plant resistance, water levels, pests, natural enemies, etc.) and compare to potential management activity costs (irrigation, fertilization, pest control practices) that could be undertaken to improve yields and reduce impact of yield-loss components (decision making)

Farmers Field School Activities

Agro-Eco System Analysis. (AESA):



Insect Zoo studies:

Non-Formal education:

Learning through discovery:

Farmers Field School Activities. Practice FFS Sessions (One month Programme):

The Farmer Field School (FFS) is typically season long training programme .However, during one month season long training programme the FFS practice sessions are restricted to four sessions only excluding post FFS activities. Each session begins in the morning and ends before lunch (one half day). The typical contents of the FFS are listed below.

- **IPM and Farmer Practice comparison trial.** This trial is conducted on a 1000 m^2 plot supported by the FFS. 500 m^2 is used for the IPM field, and 500 m^2 is used for the Farmer Practice field. This 1000 m^2 field plot is used as the Study Field for the FFS. All other activities are conducted in these fields.
- **Field Trials.** The Classical IPM Study on "Stem borer plant compensation simulation", "Defoliator plant compensation simulation", "Nitrogen efficiency including organic materials and impact of pests", "Seed Production", or other studies can be conducted in the field. Usually on one or two of these studies are undertaken by the FFS depending on major issues of the FFS participants.

Topic Specific Field Guide Activities

Are carried out in the field or adjacent to the field and cover areas related to IPM and Group Development.

Weekly Schedule:

Week 1: Opening ceremony with introductions, Ballot-box pre-test, Field walk, problems about pest/disease/deficiency, Drawing Together (team building) Ecosystem analysis, group dynamics

Week 2: Agro-Ecosystem Analysis (decision making), exercise on Predators and parasites. Crop physiology, group dynamics

Week 3: Agro-Ecosystem Analysis (decision making), bio-agents, group dynamics. Reduced Exposure to Pesticides & Pesticide Toxicity, health issues

Week.4: Agro-Ecosystem Analysis (decision making) Diseases or other topic, Group dynamics, Post ballot test

Post-FFS: Inform FFS participants of pre- and post-test scores. Make regular visits to follow-up activities

Field Trials- PAR Model

Objectives:

- *To compare IPM methods with local farmers practice on conventional methods Farmers*
- *To make the farmers to realize the benefits of AESA*
- *To make the farmers to understand the adverse impact on pesticides*

Method

1. Use the same agronomic practices for all treatments. Nitrogen applications should be basal, and one or two splits based on usual practices. If fertilizers are not the same for IPM and farmer practices, be sure to include this information on all yield graphs and tables.
2. Treatments. Use 3 to 4 replications per treatment with each plot at least 500m^2. It is better to have a larger plot size and less replication for this study because of the movement of insect pests and natural enemies when pesticides are applied.

T1. IPM methods; observation and agro ecosystem analysis

T2. "Farmer Practice" or "Conventional Method". Make a survey before the beginning of the season and do not change during the season as a result of comparison with T1.

T3. No-spray [optional, but desirable - every person should try to grow rice without spraying at least in their life - it will change your view of pesticides forever!]

3. Make weekly Agro-Ecosystem analysis of all treatments. Treat T1 as necessary based on field observations. Treat T2 based on initial survey and determination of conventional methods. Do not treat T3 with pesticides but do check irrigation, and be sure to hand weed as necessary.
4. Measure yield at end of season.

Analysis

1. Make graphs of the insect and natural enemy populations.
2. Make a cost-benefit economic analysis of all treatments. Include health and environmental impacts if possible.

Learning through Experiments:
Model:
Plant Compensation studies- PAR Model

Objectives:

To demonstrate the level of plant compensation due to damage similar to stem borer damage

Methods

1. Use IPM agronomic methods
2. There are 10 treatments which should be replicated 4 times per treatment. Plots may be small.

T1. At 14 DAT, cut 10% of tillers in 1 m^2 block.
T2. At 14 DAT, cut 20% of tillers in 1 m^2 block.
T3. At 14 DAT, cut 30% of tillers in 1 m^2 block.
T4. At 30 DAT, cut 10% of tillers in 1 m^2 block.
T5. At 30 DAT, cut 20% of tillers in 1 m^2 block.
T6. At 30 DAT, cut 30% of tillers in 1 m^2 block.
T7. At 55 DAT, cut 5% of panicles in 1 m^2 block.
T8. At 55 DAT, cut 10% of panicles in 1 m^2 block.
T9. At 55 DAT, cut 15% of panicles in 1 m^2 block.
T10. No tiller cutting: Control.

3. Cages may or may not be used. In the case that cages are not used, the actual level of damage should be computed for final analysis.
4. Sampling: Weekly sample the tiller number, % dead hearts and % whiteheads. Note any other insect, disease or rat damage. At the end of the season, measure the yield of the 1 m2 block in each replication.

Results

1. Compute the actual damage for each replication and treatment if there was any natural infestation.
2. Plot the yields for each treatment.

Discussion:

1. What was the effect of the simulated damage on yield? Was any plant compensation evident? What would happen if the nitrogen level was higher? What does this mean for usual farmer practice? Do sprays for defoliation reduce yield loss, or increase the chance for BPH resurgence?

PAR- Model

Yield and pest response to nitrogen dosage.

Objectives:

- **To understand the nitrogen response study for observation of pests and yield effects**
- **To know excess application of nitrogen results in lodging.**
- **To know the excess application of nitrogen will result in increase of diseases such as blast and sheath blight**

Methods:

1. Use agronomic practices recommended for your area for all inputs but nitrogen. Nitrogen applications should be basal, and one or two splits based on usual practices.
2. Treatments. Use 4 replications per treatment. (Treatments with manures can be introduced as well).

T1. O kg N/ha
T2. 40 kg N/ha
T3. 80 kg N/ha
T4. 120 kg N/ha
T5. 140 kg N/ha

3. Sampling: Weekly sample the tiller number, plant height, disease intensity, insect pest density, dead heart %, whitehead %, natural enemy density. Measure yields at the end of season.

Results:

Plot sampled data against nitrogen levels. Economic analysis of inputs vs. yields.

Discussion topics:

1. What was the effect of nitrogen on plant development and yields?
2. What was the effect of nitrogen on insect pests and natural enemies?
3. Which level was most profitable? Which level was not risky in terms of potential disease or lodging?
4. What do you conclude about the usage of nitrogen? What will happen to rice yields when nitrogen costs increase in twenty years with increasing petroleum costs?

PAR -Model
Simulation of Defoliation

Objectives:

- To understand the simulation effects of defoliation on yield loss
- To know whether the plant ability to compensate the leaf damage

Methods

1. Use IPM agronomic methods
2. There are 9 treatments which should be replicated 4 times per treatment. Plots may be small. Leaf cutting means to cut each leaf on the plant. 25% means one quarter of the leaf blade, and 50% means one half of the leaf blade.

T1.At 14 DAT cut 25% of all leaves in 1 m^2 block.
T2.At 14 DAT cut 50% of tillers in 1 m^2 block.
T3.At 30 DAT cut 25% of tillers in 1 m^2 block.
T4.At 30 DAT cut 50% of tillers in 1 m^2 block.
T5.At 55 DAT cut 25% of tillers in 1 m^2 block.
T6.At 55 DAT cut 50% of tillers in 1 m^2 block.
T7.At 70 DAT cut 25% of panicles in 1 m^2 block.
T8.At 70 DAT cut 50% of panicles in 1 m2 block.
T9. No leaf cutting: Control.

3. Cages may or may not be used. In the case that cages are not used, the actual level of damage should be computed for final analysis.
4. Sampling: Weekly sample the tiller number, % dead hearts and % whiteheads. Note any other insect, disease or rate damage. At the end of the season, measure the yield of the 1 m2 block in each replication.

Results:
1. Compute the actual damage for each replication and treatment if there was any natural infestation.
2. Plot the yields for each treatment.

Discussion:

What was the effect of the simulated damage on yield? Was any plant compensation evident? What would happen if the nitrogen level was higher? What does this mean for usual farmer practice? Do sprays for defoliation reduce yield loss, or increase the chance for BPH resurgence?

Specimen Collections- Diseases and insect pest

Disease Collection:

Introduction:

Diseases can be collected by collecting the plant parts which show signs of the disease. For example, for bacterial leaf blight (BLB), infected leaves of different stages of infection should be collected. When collecting the plant parts, collect the whole tiller and keep the base of the tiller moist. After returning to your room, place on the infected parts between sheets of newspaper. Place heavy objects such as books or mattress on top of the papers so that the plant parts are flat when dry.
The dried plant parts should then be glued onto a heavy large piece of white paper. If it is difficult to glue the plant part to the paper, use strips of white paper like tape to keep the plant on the paper.

After mounting, keep all sheets of papers flat and out of the sunlight. The collection can be kept in a large plastic bag to keep insects and mites out of the collection. Treat the collection with pesticide if necessary. Occasional drying of the collection will reduce pest damage.

Note that collections are only a *process* in which to learn functions, structures and names of diseases. Labels are written in the lower right hand corner of the page on which the plant is mounted.

All specimens should be correctly labeled with the following information where appropriate:

Common Name (in local language)
Name of collector
Date collected, Place collected
Ecological function
Latin name with genus, species, and order.
Thick paper with writing in black ink should be used for dry labels. Thick paper and writing in pencil should be used for specimens in alcohol.

Insect Collection:

Introduction:

Insects and spiders can be collected many ways. The best way is to sit in a field and watch the insects and spiders to observe their activity and behavior. Keep a record of what specimens are doing in the field. Collecting can be done by hand, with a sweep net, or with an aspirator. Kill insects by placing the specimens in a bag with a small amount of alcohol or by placing the bag into a freezer for an hour. Insects, especially parasites and adult moths, can also be collected by collecting larvae or eggs in the field and rearing the insects until adult parasites or other insects emerge.

Insects and spiders that are collected can be divided into two groups. First are hard-bodied insects which are usually adults. Second are soft-bodied insects, which are usually immature nymphs and larvae, and soft-bodied spiders. Hard-bodied insects should be placed on pins and soft-bodied insects and spiders should be placed in 70% alcohol.

All specimens should be correctly labeled with the following information where appropriate:

First label
Common Name (in local language)
Host (plant or insect)

Ecological function (plant feeder, predator, parasite, detritus feeder, etc.)
Second label
Name of collector
Date collected, Place collected
Latin name with genus, species, and order.

You should use thick paper with writing in black ink for labels on pins. Thick paper and writing in pencil should be used for specimens in alcohol.

Mounting large insects on pins should be done on pins on the right side of the thorax when the head is pointing away from you.

For small insects, the insect can be glued on a triangular piece of paper using most any glue (see below). Clear nail polish is commonly used as glue for this kind of mounting.

Keep the collection in a safe place away from ants and other insects. Dry the insects well using a desk lamp. Treat with insecticide if the collection is being damaged. Keeping moth balls (paradichlorobenzene) in the collection will reduce insect damage.

Note that collections are only a process in which to learn functions, structures and names of insects. The final product is nice to look at, and usually very impressive, but the goal of the collection is the actual collecting process. Collecting and mounting are good ways to get to know the insect and spider communities in your area, and to understand the ecological relationships between organisms in an ecosystem

Crop Physiology- (Rice crop - A Model)

Anatomy and function are closely related. A nose has holes (anatomy) so that air can enter the body (function). A plant's anatomy is important to study to understand the function. The vessels in the leaf (anatomy) are important for transport of water, nutrients and systemic pesticides (functions).

Each week during the crop growth, you will collect, observe and draw plants. Use the microscopes or magnifying glasses for better observations. The micro view of the leaf surface is fascinating as are all other parts of the plant. Drawing is a tool to assist in observation, remembering and for recording what you have seen. Try to spend time to make detailed and well labeled drawings.

You will find that a deep understanding of the plant is the first step in understanding the effects of disease and insects on the rice plant. You will also find out why not all injury caused by diseases, insects and rats results in yield losses. Plant compensation is important for reducing the effects of injurious organisms.

Tillering Ability in Vegetative Phase

Introduction:

During the vegetative phase, the plant is growing very rapidly. The initial two or three small plants transplanted were simple plants consisting on one stem, a couple of leaves and a few roots. As the plant grows during the vegetative phase several changes are taking place. On modern high tillering varieties, two of these changes have important implications for pest management: tillering ability and leaf growth.

Tillering ability is an important characteristic of the modern varieties. Traditional varieties generally have few tillers and each tiller is very tall. Much nutrient is used for a few tillers in traditional varieties. Modern varieties use the same nutrients for shorter plants that have more tillers and more potential for producing panicles. The ability of modern varieties to produce more tillers is related to their ability to use more nitrogen. In traditional varieties, more nitrogen result in taller plant that are likely to lodge (fall over) at maturity. Modern varieties increase the number of tillers with increasing nitrogen.

Each new tiller a really a complete plant. New tillers produce a stem, leaves, roots, and other new tillers. Tillers can be given names depending on where they emerge. The main tiller is the stem of the transplanted seedling. The primary tillers emerge from the main tiller. Secondary tillers emerge from the primary tillers, and tertiary tillers emerge from the secondary tillers. The main tiller and the primary give most of the yield for the hill, especially on short maturing varieties. Secondary tillers also have good yield but are partly green at harvest. Many tertiary tillers may not produce a panicle if nutrients, sunlight, and water are not available.

New tillers are produced from seedbed to about primordial stage. If the tillers from one plant in the hill are damaged early in the vegetative phase, more tillers will be produced by the other plants in the hill ("compensation"). Early stem borer damage does not seem to effect yield because the tillers are easily replaced.

The leaves on the tillers are also growing from seedbed to primordial stage. The leaves will emerge and later die. As the bottom leaves are dying, new leaves are emerging from the top. The process allows the plant to renew leaves that are damaged by the wind, insects, or disease. The new leaves are also able to grow larger because of the larger supply of energy from the plant as the plant grows bigger.

The growth of the new tillers and leaves is determined by plant spacing, water, sunlight, and nutrients (fertilizers) available to the plant.

Objective:
To describe the growth of vegetative stage plants in terms of tillering ability and leaf formation.
Time required = 120 minutes
Materials (per group) plants; 20 days after seeding (DAS), 15 and 30 days after transplanting (DAT), knife, pencil, papers.

Procedures:
(Do the following for each age plant)
1. Find fields of different ages and collect plants from the field. Wash all the mud from the plants.
2. Take the plants to a shady place and observe the plants. Begin by removing all the roots from the bottom so that the very bottom of the tillers is easily seen. Wash all mud from the base. Spread the tillers apart and notice how the tillers emerge from other tillers.
3. Make a map of the tillers by finding the primary, secondary and tertiary tillers. Carefully remove the tillers and note where they emerge. Find the first primary tiller and remove from the main stem. On this primary tiller, find the first secondary tiller and remove it. If the secondary tiller has a tertiary tiller, remove this tiller also. Continue this process until you have a map of the tillers on the plant.
4. Count the number of leaves on each tiller. Count the number that is dead. Notice if there are new leaves emerging.
5. Each person in the group should take a turn to explain the structure of one of the plants to the group using a map.

Discussion and Presentation:
1. Describe the pattern of tillering from transplanting through the vegetative stage.
2. Why is continuous tillering important?
3. What will happen when some tillers are removed from the plant?
4. What is the effect of stem borers on the plant in the early phase.
5. What is happening with the leaves on the different tillers? Are there dead leaves and newly emerging leaves? Way is this important?

Roots and Plant Vessels

Introduction:

Fertilizers and systemic insecticides, such as carbofuran, are often applied to rice plants. How do these nutrients and insecticides get into the plant and then move through the plant?

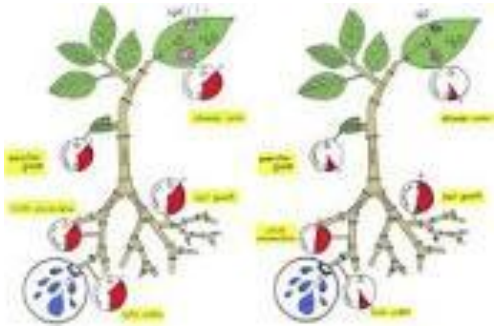
To enter the plant, the chemicals must be dissolved in water. Without water, the compounds will not be able to move either in the soil from the surface to the roots, or from the soil into the roots. Once the chemical are dissolved in the water, they are absorbed into the plant with the water.

Once the chemicals are inside the plant, the chemicals are able to move through the plant through a system of hose-like vessels between the roots and the top of the plant. Water moves up these vessels and sugars move down the vessels.

Insects feeding on the plant by sucking or chewing of the vessels ingest the insecticide. Plant hoppers and stem borers are insect pests which can be controlled using the systemic insecticides because they feed on vessels. Hoppers suck on the vessels, and stem borers eat the vessels while feeding inside the plant.

After the systemic insecticide moves to the leaves of the rice plant, water from the vessels is exuded each evening. This is the small droplet of water found on the tips of the leaves early in the morning. This drop of water on each leaf contains the systemic pesticide. The drop falls back in the water or evaporates each day. If natural enemies come into contact with the water they will be killed by the systemic pesticides. The drop of water often falls on natural enemies or natural enemies drink from the drop of water.

This activity will show how water solutions move through the plant.



Experiment on crop physiology:
Objective:
1. To describe how systemic insecticides move through the plant.

2. To explain how systemic insecticides control insects sucking or chewing on plant vessels

Time required = 120 minutes (Whole time not used. Best to run activity while doing other activity.)

Material:

Water, red ink or food coloring, 2 cups per group, plants and 2 straws

Procedure for one group:

1. Go outside and find many kinds of plants including rice seedling, grasses and other plants.
2. Add water to the 2 cups and place several drops of the red food coloring. The water should be dark red.
3. Place the plants in the cups with the stems in the cups. Also place the straws in the cups. One straw should be flattened first. Place the plants in a bright place.
4. Wait 90 minutes and observe the plants. What has happened to the color of the leaves? How has the red coloring moved in the plants?
5. What do you think happens with rice in the rice field when systemic insecticides are used? Where is the insecticide in the plant? What kind of insects suck on the fluid in the plant vessels? What kind of insects chew on the plant vessels? What about insects that feed on the leaf edge? Do they also feed on the main vessels?
7. What happens after the solution reaches the tip of the leaf? Have you noticed the water on the leaf tips in the evening and morning? Where does this water come from and what does the solution contain? How might the solution effect natural enemies in the field? How about farmers walking in the early morning field?

DISEASES MANAGEMENT

Background:

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, MLO, fungi, virus and nematodes) 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 have long-term control. There will be four activities for discussing diseases. The topics will cover management methods, observation methods, epidemiology (the spread of disease), and causal organisms.

The most important first step in thinking about diseases is to realize that diseases must be managed not controlled. What is the difference? Management means a complete set of activities that support each other. Management means that these activities are carefully planned and are implemented over several seasons, not controlled within a single season. Management included control methods for prevention, and control methods to slow 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. Management requires someone who can observe larger areas of disease incidence and levels of infection.

For an example, management of tungro in rice would be impossible without observing the larger picture of disease infection levels. The management system requires distribution of new varieties, careful monitoring of GLH, monitoring of disease incidence, planting time coordination, and sometimes a break in planting rice. These are activities that are done by individual farmers, but managed so that the activities are carried out together. Think about the management needed to control other diseases such as polio, malaria, and small pox!

What are management activities? Below is a summary of activities.

Prevent the introduction of inoculums into the field in order to delay the beginning of infection. This can be done by;

a. Allowing only disease-free seed and planting materials (example, root stock for trees) into an area. This can be done at any level of organization.

b. Destroy sources of inoculums such as materials in nurseries and fields with diseases. For large scale removal, it is useful to have funding (or insurance?) to compensate farmers for destruction of sources of inoculums (fruit trees, planted seasonal crops such as soybeans).

c. Small areas planted to a particular crop before the main growing season for the crop should be avoided. These small areas build up inoculums which is then carried over to the next season.

d. Farmer practice to keep disease inoculums from entering new fields. This is done by careful

purchase of materials in the market, seed suppliers and plant sellers. It is also important to keep nematode infested soil from moving from field to field on the shoes of farmers, animals, and plows.
e. Sanitation is important to keep inoculums from one crop getting into the next crop. Potato blight (*Phytophthora infestans*) can be reduced by removing excess old potatoes from fields.

Prevent the development of inoculums after it enters the field. Removal and destruction of inoculums can be done before planting, during the cropping season and after the crop is harvested. Deep burial of diseased plant materials by plowing, removal of diseased plants, burning of crop residue while in the field or after collection, flooding fields, and repeated plowing to expose fields to sunlight (for nematodes) are some activities that may be beneficial. The effectiveness will depend on many factors which must be analyzed for each case.

Crop rotation is important if the rotation reduces inoculums. Rotation of tobacco and tomatoes for example is not rotation for the diseases which infect both crops. Crop rotations should be observed since there are many pathogens that survive on numerous types of both living and dead plant materials.

Fertilization may increase or decrease diseases. Most people believe fertilizers only increase diseases. However, there are numerous examples in which addition of nitrogen, potassium, or calcium actually reduced the effects of certain fungi.

Management of the micro-climate is also important. Each site has a different micro-climate each season. A shady slope in the wet season will be different from a sunny slope in the same season. Crop planting times should take into consideration dominant diseases in the area and the effect of the micro-climate.

Objective:

1. To outline management activities that could be organized for an area to reduce disease incidence.
2. To use brain-storming techniques to increase/encourage inputs from all sources when problem solving or planning.

Materials

Newsprint paper (4 pieces per group) and marker

Steps

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

1. Appoint one person as the secretary who will write on the large pice 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 "Wide-Area Disease Management" on the top of a large piece of paper.
3. The Facilitator should read the above Background for the whole group. Each member should make notes of thoughts that come to them while listening to the reading.
4. After the reading, the Facilitator should ask the following question: "What are activities that can be done in our village to manage diseases on our crops (all crops)."
5. The group members should tell the secretary their idea. The secretary will write down the idea. NO COMMENTS ARE ALLOWED BY OTHER MEMBERS AT THIS POINT. If any member makes comments, the Facilitator must ask the person to be quite.
6. Continue writing down ideas with no discussion until the first page is full.
7. After the page is full, discuss each idea beginning at the tope 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.
8. Present the summaries of ideas to the whole group.
9. If there is time, do the same process with the following question, "What can extension staff do to help manage diseases in our village?"

MANAGEMENT OF WEEDS

Introduction:

Weeds reduce yields by competing with the rice plants for sunlight, moisture, and soil nutrients. Weeds may affect farming in many ways. For example, fertilizer applied my not increase yields in weedy fields because weeds absorb nitrogen more effectively than the rice plants. Also weeds are harmful because they may be alternate hosts for insect and disease pests of rice, and provide shelter for rats. Usually weed problem is more serious in dry land and dry seeded rain fed than in lowlands.

However, if both left to grow in the field it can result to reduce yields.

Objectives:

1. Classify weeds according to economic significance.
2. Identify factors that contribute to severe occurrence of weeds in the field.
3. Develop management strategies for weeds.

Time requirements: 90 minutes

Materials required: marker pen, crayon, pen, and notebook

Procedure:

1. Each group should assess weed population in different areas in the rice fields.
2. Each group should collect as many different species of weeds from the rice field.
3. Each group should classify weeds collected according to their gross morphology, qualifying characteristics (i.e. perennial or annual) and distribution.
4. Process data.
5. Distribute discussion question to each group.
6. Present and discuss answer with the big group.

Cyprus

Discussions questions

1. Among weeds collected, which weeds are difficult to control? Why?
2. Based on your experiences, on what stage of the rice crop is critical to weed competition?
3. What are weed management practices can you recommend for direct seeded rice? For transplanted?
4. What are your general recommendations to manage weeds?
5. How will you justify that weeds are also useful to farmers?

Rats

Rats are one of the most consistent and serious pests of rice. The main problem of rat control is that rats must be controlled by community action, and organizing communities is not an easy task.

There are a few differences between rats and insects that make implementation of management different. First is the ability of rats to stay in one area even though there is no crop. This means that we can use damaged caused in one season to initiate controls in the next season. The other difference is the methods of control. Rat control must be organized over a wide area to be very effective. Rat drives, baiting, digging, and any other method of control is most effective when done as a community.

Rat Population Growth

Introduction

Rat populations increase very rapidly because rats have many offspring very often. Rats can live for one year or longer. Females may reproduce up to 4 times a year and have an average of 6 offspring in a litter. This exercise is designed to visualize simple population growth for one year.

Objective

1. Able to show rat population growth over several months using nails, seeds or other items.
2. Able to ask leading questions about rat populations to bring out two management points; (1) It doesn't matter how many rats were killed, it only matters how many rats remain in the field, and (2) continuous rat control is important to keep populations low.

Time required = 120 minutes

Materials (per group)

2500 Bengal gram seeds, glue and paper, pencil and pen

Procedure

1. This can be done using nails on wood or seed on paper on the piece of large paper.
2. In the first section place 2 seeds. One nail represents one female rat, and the other represents a male rat.
3. Move to the first month. Add 6 seeds for 6 offspring from the original pair of rats. 3 rats are females and 3 rats are male.
4. Move to the fourth month. Add 6 seed for 6 offspring from the original female, then add 18

seeds for the 3 females in first month (3 females times 6 offspring each). Half of the nails are female rats.
5. Move to the seventh month. Add 6 seeds for 6 offspring from the original female, then add 18 seeds for the 3 females in first month (3 females times 6 offspring each). Add 72 (12 females with 6 offspring each) for offspring from females in the fourth month. Half of the seeds are female rats.
6. Continue this process for the 10th and 13th months.

Write on the paper the total number of rats for each of the months, and the cumulative total from month to month.

Discussion and Presentation

1. How many rats are produced in one year? (One section is three month)
2. If half of the rats are killed in the seventh month, how many rats will be produced by the end of twelve months?
3. If there are 10 female rats in the first month, how many rats will be produced in the 13th month? If you organize a rat drive and kill this many rats, will you be very excited and call your rat drive a success? How many rats are remaining in the field? Do you think the rat drive was a success still? How many rats will be in the field the next month considering reproduction? (Note that reproduction is even greater after many rats are killed because of less competition for food and space!)
4. What is the meaning of the saying "It doesn't matter how many rats were killed, it only matters how many are left in the field to reproduce".
5. Many farmers say that if you kill rats, they will bring their friends and completely destroy a field. Can you explain why fields are destroyed after one rat drive? (remember reproduction, and that reproduction is faster when the population is lower).
6. Why is it important to begin killing rats early in the rice? Why is it important to keep killing rats all season long? What would be the population of rats after 6 months if only 1 female from each group of six offspring survived?

Totals by month; 1st month-6/ 4th month-24/ 7th month-96/ 10th month-384/ 13th month-1536/ Total 2046!!!

INSECT ZOO

Introduction

The goal of the Insect Zoo is to help you learn about insects and their natural enemies by direct observation and manipulation. Insects and spiders are more interesting when seen alive and active. Think of going to the zoo...a tiger that is tearing the flesh from a rabbit is much more interesting than a snoring tiger hidden in a corner. Imagine a spider sucking the juices from a writhing first instar stem borer larva or leaf folding by a leaf folder. A living organism is much more than what is seen in an alcohol filled jar.

In fact some things can only be recognized when living - the small water striders (*Microvelia*) is an example. The ripples on the water as the water striders glides across the water surface are their most distinguishing characteristic. They are like sharks; they cruise around in the water and when a larva or BPH drops on the water, a whole group will attack together.

The *activity and behavior* of insects and natural enemies can only be seen on live specimens. The Insect Zoo will give you many living specimens for demonstrations that will keep farmers and others more involved while watching spider females eat their mating partners, and help them remember better something about the message that predators and parasites are friends in the field.

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

There are many ways to rear insects and their natural enemies. Many parasites can be obtained directly from their host by collecting eggs, mature larva, and pupae from the field and placing in a container of some type. Any plastic, glass, or paper container will work. Place the collected specimens in the container and merely wait. If the specimens were parasitized, the small wasps will emerge. Preying mantis egg cases, stem borer egg masses, large caterpillars, and hopper eggs are the easiest and most often parasitized specimens to rear.

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

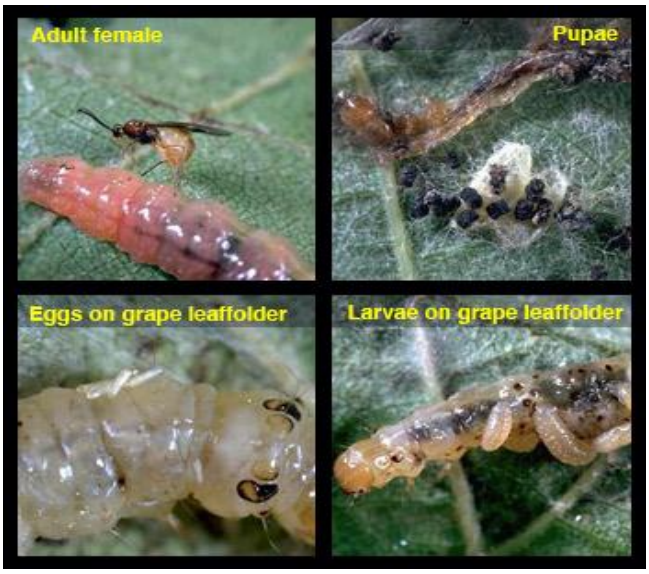
For parasites that are not collected from hosts, it is sometimes possible to put "sponge plants" in the field. This means that from reared insects you have plants in pots with egg masses or larvae. These plants with the host are placed in the field for up to four days to attract the parasites. The parasites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

Objective

Rear the following insects and spiders for the life stages shown to understand the functional role.

- Hoppers: adult to adult
- Stem borer: adult moth to first instar
- Leaf folder: adult moth to first instars
- Rice bug: keep nymphs and adults for one week
- Various larvae: larva to adult
- Hunting spiders: keep for one week
- Web-making spiders: keep until makes web
- Ladybeetle larvae and adults: keep for one week
- Other predators: keep for one week
- Stem borer egg mass parasites: keep egg masses until adult parasite emerges
- Leaf folder larval parasites: keep larva until adult parasite emerges
- Other caterpillar parasites: keep larvae or parasite pupae (especially Apanteles) until adult parasite emerges
- Demonstrate the following processes using the insects and spiders in your Insect Zoo. These are the most important processes in the rice ecosystem which effect the crop and pest dynamics.
- Demonstrate hopper feeding on the plant
- Demonstrate hopper development from nymph to adult
- Demonstrate eggs in the stem of the plant
- Demonstrate hopper mating
- Demonstrate egg laying and egg masses of collected adult stem borer moths
- Demonstrate emergence of first instars stem borers
- Demonstrate eggs and larvae of leaf folders
- Demonstrate rice bug feeding on the panicle
- Demonstrate adults of field collected larvae
- Demonstrate predation of hunting spiders (number consumed per day) using hoppers for food
- Demonstrate web-making of web-making spiders
- Demonstrate moth predation by web-making spiders
- Demonstrate larval and adult ladybeetle predation (number consumed per day) of hoppers

Demonstration of predator-prey relationship Parasites emerging from especially *Apantles* parasite pupae



Demonstration of leaf folder egg parasites

Time Requirements for Insect zoo

Each week at least two hours is needed special for the Insect Zoo.

Materials

Plants, cages, small plastic bottles, plastic bags

Procedures for Rearing

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

General Rearing Methods

1. *Bottles and Plastic Bags* are very useful rearing tools. Always carry a couple in your pocket or bag. If egg masses, larvae or nymphs are found in the field, collect and place in the bottle or plastic bags. The bottle should have a piece of netting over the mouth of the bottle. Add plant material daily for herbivores. Transfer to larger cages if necessary. Try to collect older larvae that will quickly pupate. Parasites will also emerge from egg masses, larvae and pupae.

2. *Simple Cages* can be made using waste materials such as transparent glass or plastic bottles. Place leaves and stems in the bottles with insects and cover with netting. For soft drink bottles, place a bouquet of stems and leaves in the bottle and cover with large plastic bag. For seedlings, invert the plastic bottles which have one end open and other end covered with netting material.

3. *Field Cages* are useful to cover infestations of large larvae, hoppers, and other insects. Make cages from large plastic bags, or netting materials. Use bamboo sticks to hold the cages above the plant.

4. *Potted plants and Cages* is useful especially for demonstrations and exhibitions. Grow your own plant in the pot, or transplant from field grown plants. For cages use netting suspended strings or frames, or use plastic bags with netting glued over one end. Expensive thick stiff plastic is also very useful.

5. Be Creative! It is surprising where insects can be reared. Use discarded cans for pots, and transparent plastic bottles for cages. Clear glass jars and small plastic containers will suffice for most needs.

Rearing Tips for Specific Insects

These are only tips. You can probably improve on all of them.

1. *Plant hoppers*: Place at least 3 male and female pairs in cages on young (30-40 HSS) plants. Allow mating and egg laying. After nymphs emerge (8 days after egg laying) remove excess nymphs to other plants when the nymphs are in the second instars. If the plant becomes brown, move the nymphs to new green and healthy plants. Alternative method is to place hoppers in cages on plants in the field. Be sure all natural enemies have been removed first.

BPH eggs BPH

2. Stem borers: Collect adult moths in the field using hands or sweet net. The best way to collect is with a bottle so that the moth is not damaged. Place the moths that look alike in cages on plants. Observe the egg laying. Wait for emergence of the first instars from the egg.

3. Leaf folders: Collect adult moths in the field using hands or a sweep net. The best way to collect the moths is with a bottle so that the moths are not injured. Place many leaf folder moths in cages on young plants. Observe egg laying and wait for emergence of the first instars from the eggs.

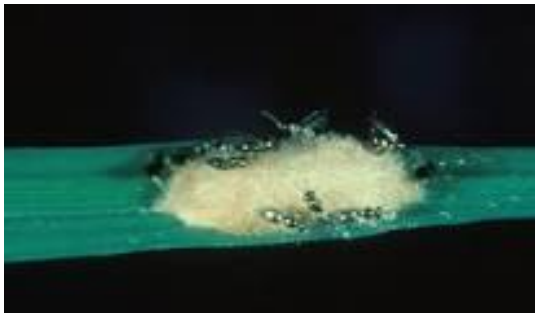
4. Rice bugs: Collect nymphs and adults from the rice field. Place the insects on older plants in the milky stage. Observe feeding and egg laying.

5. *Other larvae*: Collect larva in the field. Old larvae are easiest to rear to adult. Place the larvae in cages on plants of the same age as those in the field. If the plant is consumed quickly, move the larva to a new plant. Observe pupation and adult emergence.

6. *Hunting spiders*: Collect hunting spiders in the field. Place in cages with or without plants. To demonstrate feeding, do not feed the insects for at least one day before demonstration. On the day of demonstration, place several types of insects from the rice field in the cage. To show the number of hoppers eaten in a day, place many hoppers in the cage (count them first) then leave for one day. Count the remaining hoppers the next day.

7. *Web-making spiders*: Collect web-making spiders in the field and place in cages on older plants so the spider can make a web. Observe web-making. After the web is made, place a moth in the cage and observe the results.

8. *Larva and adult ladybeetles*: Collect larva and adult ladybeetles and place in cages with or without plants. Place young hoppers in the cage to observe feeding.
9. *Stem borer egg mass parasites*: Collect egg masses in the field. Place in small plastic bottles. Wait and observe emergence of parasites or first instars.



10. *Leaf folder parasites*: Collect older parasitized leaf folder larvae and place in plastic pot. Wait for emergence of parasites.
11. *Caterpillar parasites*: Collect older parasitized larvae and place in plastic pot. Wait for emergence of parasites.
12. *Parasite pupae*: Collect parasite pupae (especially Apantles) and place in plastic pot. Wait for emergence of parasites

Life Cycles and Food Webs

Introduction

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

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

As a trainer working with farmers, you must begin to integrate these two motions together into a smooth acting dynamic ecosystem. Seeds germinate to be eaten by insects that lay eggs that are parasitized....for example. Every life cycle is part of a food chain.

In this exercise, you will have to put the two systems together so that they are functional. This will help you to understand that interactions have a time frame. For example; the life cycle of hoppers (brown, white-back, and green) all begin with a egg stage inside the plant. In the next stage, the nymphs feed on the stem or leave by sucking. Finally adults mate and lay eggs on the same plant or migrate to other fields. During each stage, different natural enemies attack the hoppers. During the egg stage, parasites complete their own egg/larva/pupa/adult in the hopper eggs and kill the eggs, and mirid bug predators suck on the eggs. During the nymphal and adult stage, hunting spiders, water striders, lady beetles, and other predators feed on the hoppers. Parasites live on the nymphs until nymphs are adults. Web-spinning spiders feed on flying hoppers as the move in the field.

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

For this exercise, you will have to integrate much of your knowledge into a big picture. It will not be easy to put the pieces together Also for this exercise you should think in terms of "guilds". Guilds are group organisms that have similar types of life cycles and share food sources and are usually attacked by the same natural enemies. Hoppers are one example above. The many species of stem borers are another guild. Hunting spiders includes many species that hunt in a similar way and have similar prey. Try to use major guilds for this exercise than individual species.

Objective

After this activity you should be able to explain the interaction of the ecosystem factors using both life cycles and food chains for at least one guild of insect pests.

Time required = 120 minutes.

Materials

Paper, pens, pastels, IPM TEXTBOOK

Procedure

1. Each group should choose a guild to analyze;

Hoppers, stem borers, leaf folders, leaf feeding caterpillars, caseworms, black and other bugs, rice bugs, gall midge, rats.

2. Draw a large circle and write in the general stages for insects of the guild around the circle (see example below).

3. On one side make a list of the stages of the insects in one column. In the next column, make a list of natural enemies (by guild) which attack each stage.

4. On the drawing, draw a circle for each natural enemy which attacks a particular stage of the insect. On the natural enemy circle, write the stages of the natural enemy's life cycle. If their are natural enemies of the natural enemies (example, a spider that eats another spider) then make a third level of circles for these natural enemies. (USE YOUR TEXTBOOK TO GET MORE INFORMATION).

5. After finishing the diagram, do a short role play with another group. One group IPM experts is advising another group of farmers about the insect that was chosen. The group of IPM experts is very smart and they know that asking questions and making discussion is better than giving simple answers. So the IPM experts begin a process of discussing with farmers about the life cycle of the pest insect. (Most farmers know this, but farmers like to talk. Let them talk as much as they like by asking questions).

Next, the groups of IPM experts begin to ask about the natural enemies of each stage. Many farmers know this, but the IPM experts may have to help them by giving hints. (Example: What about parasites?)

Work through the whole life cycle.

6. Change roles for each group and repeat the activity.

7. Ask the following questions:

a. What would happen to natural enemies if there are no insect pests?

b. Do you think insect pests can be beneficial if at low populations? Why are they important?

c. In the system, what will happen if you spray broad-spectrum pesticides?

Toxic Compound (Pesticides) Related Issues: Poisons in Agriculture

Introduction

Pesticides are necessary to in some fields, in some years in areas. In many seasons, many rice fields do not need pesticides. Pesticides are poisons. They are very dangerous to both the person who uses the pesticides and to those that are living or playing near the fields where pesticides are used. These poisons kill aquatic animals (fish and frogs), beneficial predators and parasites, and other beneficial animals such a pollinating bees. There is no use of pesticides that can be called "safe" to everything in the ecosystem. Even the very selective insecticide, Applaud, causes problems for the growth of shrimp and prawns. There is no "safe use of pesticides". We can only avoid their use and reduce exposure when used.

Predators, parasites, pathogens, resistant varieties, growing a healthy crop, and proper monitoring of the fields are methods to reduce the population growth of potentially harmful insects and rats. Pesticides are not the "last method" to use as commonly thought. They must be integrated with other aspects. Seed treatments are a good example of how pesticides are used before other methods, but used in a way which reduces their impact on natural enemies, on the environment and human health. In general, pesticides should be used as a "last method" because they do have many bad effects and are expensive in terms of actual "out-of-pocket" costs.

When pesticides are needed to reduce economic losses by insects, they should be used correctly and carefully. The first step is to know the area to be sprayed, and the proper amounts. Care should be taken in measurement and handling of pesticides. The second step is the actual application of sprays in the field. Proper protection is needed in field application and possible with simple adaptation.

Poisons in Agriculture: Health Aspects

Introduction

Pesticides are poisons which cause physiological changes that result in the death of insects and other organisms such as humans. Most pesticides attack the nervous system of organisms, both invertebrates (insects, spiders, etc.) and vertebrates (fish, frogs, people, etc.). The carbamates and organophosphates both interfere with the correct transmission of nerve pulses. The action of interference can be the result of a high single dose (common in suicide by insecticides), or over a long period such as in farmers and children working and playing in fields with pesticide applications.

How are the poisonous effects of insecticides measured? There are many types of studies done before a pesticide may become registered for general usage. Some of the tests are the effects of chemicals on skin, on eyesight, and on moist tissues such as lungs. There are also tests to see how much pesticide is needed to kill insects, and mammals. For most of these tests, rats and rabbits are used in large numbers. For example, insecticide is sprayed in the eyes of these animals and the reactions are noted.

Test on the dosage of insecticide which kills test animals are called Lethal Dosage tests. Basically the process is simple and depends on the fact that not all animals will die with the same dosage because some individuals are more sensitive than others. If a very low dose is applied to 100 individuals, only a few individuals will die. If a very high dose is given, then most of the 100 individuals will die. The dose at which 50 of the 100 (50%) die is called the 50% lethal dosage or LD50. The dosage at which 90 of the 100 individuals (90%) die is called the LD90. This is a moderately useful measure, except that even at low dosages there is still an LD10 in which 10% die. What does this 10% probability mean in another example? It means that there is a probability that for every 10 people that cross the road, one will die while crossing the road. In other words, 10% probability is still very high. Dosage for mammal is usually measured in mg/kg. This means that a LD50 of 1 mg/kg (the oral LD50 for Temik) for a person who weighs 50 kg is about 50mg, which is a very small quantity. Lethal dosages are usually given in both oral (through the mouth) and dermal (exposure to skin) levels.

But pesticides cause other effects besides death. Other symptoms of pesticide exposure include nausea, dizziness, headaches, fatigue, and diarrhea, irritation of nose, eyes, and throat. Recognition of these effects is an important part of pesticide safety and in your job as an IPM field expert. These and other effects of pesticide exposure will be explored in this activity with demonstration of pesticide effects on animals.

- Natural enemies are usually more susceptible to insecticide that pests because natural enemies usually do not build up resistance. What happens when a low dosage is applied to the field (i.e. a dosage that is LD_{50} for BPH, but LD_{90} for natural enemies)? Poisoning Symptoms
- Use the following list. Go through the list and check any symptoms you have seen or about which farmers complain.
- After spraying have you are had the following symptoms immediately or within a few days:
- Mild symptoms
- Irritation of eye, nose, or throat
- Headache
- Dizziness
- Fatigue
- Diarrhea
- Moderate symptoms
- Redness or itching skin
- Upset stomach
- Blurred vision
- Extreme weakness
- Excessive perspiration
- Rapid heartbeat
- Severe symptoms
- Pinpoint pupils
- Difficulty in breathing
- Unconsciousness

Effects on pesticide exposure.

PESTICIDES

A major problem of pesticides is their effect on "non-target organisms". Most pesticides are very toxic to predators, parasites, fish, and people who come into contact with these chemicals.

For other types of insects there are other pesticides. A major new pesticide is Bacillus thurengiensis usually called "Bt". This insecticide is active against most Lepidoptera (butterflies and moths). The insecticide must be consumed while most insecticides only need contact. Also the insect does not die as quickly after eating Bt than when sprayed by a broad spectrum insecticide. In this activity, we will look at a selective pesticide and compare with a typical broad spectrum pesticide.

Objective

Demonstrate the difference between selective and broad spectrum pesticides.

Materials

Plastic bags
Spiders and caterpillars collected from the field
Small fish, and plastic buckets
Monocrotofos and Bacillus thurengiensis
Cups, netting, rubber bands and sprayer

Steps

1.Collect caterpillars, spiders and other natural enemies from the field. Keep the caterpillars on soybean plants so that they don't die. The plants should have the roots so there are enough leaves for the insects to live on for two days.
2.Place the natural enemies in two cups and over with netting.
3.Place the caterpillars on the plants in cups with water. Prepare two cups.
4.Place fish in two plastic containers.
5.Prepare monocrotofos in hand sprayers and Bt. in another hand sprayer. Use typical field dosage (1-2 ml/I)
6.Spray one of the cups containing natural enemies with monocrotofos and one cup containing enemies with Bt.
7.Spray one of the cups with caterpillars with monocrotofos and the other with Bt.
8.Spray one of the plastic containers of fish with monocrotofos, and one with Bt.
9.Observe the results after one hour and after one day. If the larvae haven't died in one day, observe again after another day.

Discussion questions

10. What are the results of the treatments? Prepare a table for presentation of results.
11.Why are selective pesticides useful for secondary crops? Why is it important to use selective pesticides?

Carbofuran, Carbamate Spray and Spiders

"Systemic" pesticides are those pesticides that are absorbed by the plant and the pesticide is able to move through the plant through the network of plant vessels. It is commonly said that systemic pesticides are safe for natural enemies because they compounds are in the soil and in the plant. But how do the pesticides finally get into the soil? Where is carbofuran broadcast? Is there any difference in the application of granular carbofuran and liquid sprays?

In this activity we will look at the effect of carbofuran on spiders. The effect will be compared with a neutral control and a sprayed BPMC.

Objective

Demonstrate the effects of carbofuran on natural enemies.

Time required = 120 minutes.

Materials

Plastic bags, 3 cups, netting for the cups, 3 rubber bands, water, carbofuran, liquid carbamate (eg. BPMC), natural enemies, hand sprayer (1 liter for indoor plants), pencil and paper. (Try also some herbicides, and fungicides).

Procedure

1. Go to the field with plastic bags. Collect spiders and predatory beetles.
2. Return to a shady place. Set up three cups with the names "carbofuran", "carbamate", and "control" written on them. Add water so the cup is half-full. In the cup for "carbofuran" add a small amount (two pinches) of carbofuran to the water and mix so the carbofuran begins to be dissolved.

3. Now in each of the cups, add the same number and same kind of natural enemies. Cover the cups with netting and rubber bands.
4. In the cup labeled "carbamate", spray the inside with the hand sprayer. The concentration and dosage should be the same as in the field.
5. Watch all three cups for changes in activity or death of natural enemies. Record the time of activity changes and deaths over 45 minutes.
6. What happened? How did the natural enemies in the control compare with the other treatments? Why did natural enemies die in the carbofuran treatment? Do spiders and beetles walk on the water in the field? What is the significance of a basal application of carbofuran?
7. Present your results and answers to the above questions to the other groups.

Spraying

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 cloths, and respirator are impossible to implement for most farmers because of the cost. But all these articles can be substituted; plastic bags for gloves and boots, large plastic sheet cut like a rain poncho or apron, a hat and cloth for the nose and mouth.

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 90o angle to the wind.

Remember that when you broadcast carbofuran in the water, you are walking in a soup of water and dissolved carbofuran.

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 batik dye, white pants and shirt.

Procedure (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 make reduce exposure to the spray liquid.
2. Fill the tank with water. Add red batik dye. Add a lot so that the water is very red. Close the tank and shake the tank to mix the water and dye.
3. Now spray 500 meter square of the field with the tank of water. Others should measure the time required and observe the spraying.
4. After finished spraying, empty an 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. Present you observations, discussion and clothing to the other groups. Discuss "Is there really '*safe application*' of pesticides?"

Ice-Breakers, Energizers and Team Building Exercises

- Ice Breakers
- Energizers
- Team fun
- Team skills

Introduction

Facilitators should build up a repertoire of activities that can used for interesting opening that help participants to become comfortable with each other ("Ice Breakers"), activities that boost the energy level of the group after visiting the field or after a break ("Energizers"), activities that are just fun to do in groups and make getting together a better time ("Team Fun"), and activities that build team capacity through learning techniques for planning, organizing, and action ("Team Skills").

The term "Team" is used here to emphasize that a group need to work together with common goals for common interests and that teams often have structure. There are coaches, captains, and players with various positions. No team can work well without each team member, and the team succeeds more often when everyone works together while each improves individual skills and commitment.

During the cycle of the FFS over one season, energizers and team fun might be used more at the beginning of the season, with more emphasis on

Team Skills near the end of the season, especially in preparation for community organizing.

Remember that training should be enjoyable for the facilitator and FFS members. Ask members of the group to lead other activities like warming up exercises at the beginning of each meeting, or other activity that they may have learned at another training program.

Ice Breakers

- Introduce neighbor
- Expectation picture
- Throw a ball
- Name memorization in circle
- Money under chair
- Air numbering

Energizers

- Coconut and other songs
- Group words (boy - hmmm, girl - clap, cow - stomp)
- Parasite (pen in bottle)
- Ballons on leg
- Number on paper (practice makes perfect)
- 20 questions
- Give characteristics game

Team Fun

- Water passing
- Broken squares
- Strings

Energizers

- Mini-tower and bridge (leadership style)
- Message passing (communication)

Farmer Field School- Follow-up Activities

The following is a short list of activities. The possibilities are numerous, but will require action on the part of facilitators and the group they get organized.

Farmers' Planning Meetings are one step towards farmers determining what type of follow-up activities is appropriate to their interest, time availability, and funding situation. The planning meeting should try to assess the common problems the members are facing, and establish goals towards which to work. Work plans and success criteria should also be developed, although these will usually have to be undertaken at a second meeting established specifically for that purpose.

Farmer to Farmer FFS

Problem Specific Field Labs

IPM Clubs: ARE to carry out follow-up activities. The Clubs usually focused on non-IPM problems, but often related to agriculture. Like many organizations, the name merely reflects its history and not its focus. The Clubs have officers, local budgets, and action plans.

IPM Labeling of crops

IPM Villages

FFS that focus on developing a block of IPM fields with lower pesticide inputs

IPM Trainer Association:

Trainers make a newsletter and sent it among themselves for reading and comparison of efforts with their self-proclaimed goal of training at least four FFS each year. Personal opinions and information, research results, and progress reports are included in the newsletter.

"Entering Pesticide Free Zone"

This would be a title displayed along the side of the road as one travels into an area where IPM has advanced to the point where pesticides have been replaced with non-pesticide plant protection methods,

Training Evaluation

There are numerous ways for a facilitator to evaluate the progress of one training season, but four methods that have been widely used are explained below.

Ballot Box evaluations are field based methods that use real specimens and field situations to test field abilities. The Ballot Box test should be given before and after training with levels of difficulty that are the same. The questions on the test should be developed before the beginning of the season and relate to the core objectives of the course. Questions should focus on;

- agronomic practices and plant compensation
- recognition of pests, natural enemies, diseases
- recognition of damage from pests, diseases, rats, and birds
- management of pests, diseases, rats, and birds
- other areas covered in the course

The mechanism of the test is to write a question on a thick paper board and mount it on a stick in the field. Questions should be multiple choices. The board and stick are placed like a sign in the field next to a real condition or object that is being asked about in the question. For example:

1. What caused this damage?
A) Stem borer
B) Rats
C) Tungro

The sign should have a string connecting the sign to the plant part showing the damage. The participant will then mark A, B, C on the answer sheet for question one. Alternatively, each farmer is

given many small pieces of paper (Ballots) with the same number specific for him or her. On the small containers(ballot box) marked A to C the farmer can put in their Ballots. If the correct answer is A, then the person puts their number in the A container.

Twenty to thirty questions should be prepared for the test. After everyone has taken the test, the facilitator should walk with the group to each question and determine the correct answer. If the question or answer is not clear, the group or facilitator may decide to discard the question.

Written Exams can also be used together with the Ballot Box. Of course it is important to consider the literacy level of the group, and the knowledge of names or technical terms. The names used in one village, may not be the officially accepted names nationally and this can lead to confusion. Written tests must be tested for clarity beforehand, and checked to ensure local applicability. Remember that knowing the name of something is not important for field management, but knowing it's function and ecological attributes is important. Don't be academic about names. Also don't be academic about definitions. Be practical and keep tests focused on real issues, skills, and knowledge.
Give the test before and after training. After the test, always review together to determine the correct answer. Discard unclear questions.

Field Walks are the best evaluation method because there is time to clarify questions and answers. Field Walks are basically walking in the field in pairs (facilitator and farmer) with a predetermined list of questions. The facilitator should have already prepared questions, and know parts of the fields where the questions can be used. Questions will be similar to the Ballot Box. The list of questions should not change significantly between persons and from the beginning and end of training.

A few do not do's also:

- Do not use pictures (photographs or drawings).
- Do not assume the name of something is the same everywhere.
- Do not assume anyone knows the nationally accepted proper name.
- Do not use Latin names whenever local names are available.
- Do not assume your question is very clear (they never are!).

Quality Checklist

The following questions can be used to assist an observer in examining the quality of IPM training in all IPM training contexts. These questions identify the key points in an IPM activity that must be present if the quality of the process of training is to be maintained. While most of these questions can be answered by "yes" or "no", don't stop there. Explain why you answered "yes" or "no". This checklist can also be of used as an outline for reports on IPM training.

"What's this?"

1. Are questions answered by further probing or leading questions?
2. Do probing questions concern functional relationships in the agro ecosystem?
3. Are participants able to define functional relationships in the agro ecosystem?

Agro ecosystem Activity

1. Before the activity begins are participants told the goal of the activity and the process to be followed in the activity?
2. During observation do participants get into the field?
3. Do participants look at all parts of the plant as part of their observation activity?
4. Do participants note down what they find?
5. Do participants collect specimens?
6. Are observations summarized in the agro ecosystem drawings?
7. Does the leader pose problems, ask questions relevant to the drawings, or use the list of questions in the Field Guides to encourage participant analysis of the drawings?
8. Does discussion take place concerning field conditions?
9. Are "what if" scenarios posed by the leader and discussed by the participants?
10. Are previous week's agro ecosystem drawings used for comparisons to the situation this week?
11. Are field management decisions taken and critically examined before acceptance?
12. Are other factors considered in addition to the economic threshold in decision making around control issues?
13. Are participants active and working together in the small groups?
14. Can participants state the difference between pests and natural enemies?
15. Are decisions based on levels of insect populations and analysis of their functional relationships in the rice field?
16. Does the leader, by means of questions, help the participants to analyze the activity and what they have learned?

Special Topics

1. Before the activity does the leader explain the goal and process of the activity?
2. During the activity are participants involved and active?

3. Are group activities dominated by one individual?
4. Can participants present results stating or summarizing what has happened and why?
5. Can participants state what they have learned from the activity?
6. Does the leader ask open ended questions to: help participants examine what happened during the activity; generalize from the activity; apply what they learned to "real life"?

Group Dynamics

1. Before activity does the leader tell participants the goal and process of the activity?
2. Are all participants involved in the activity?
3. Does the leader ask open ended questions to: help participants examine what happened during the activity; generalize from the activity; apply what they learned to "real life"?

Ballot Box

1. Does the "ballot box" test field based knowledge?
2. "Ballot box" questions should not have Latin names, but are they still used?
3. Does the leader use the "ballot box" as a learning reinforcement tool by reviewing each item with the participants?

Evaluation of training impact

- Economic benefits
- Environment and health benefits
- Community organization and self-funding

Economic benefits

The most sought after measures of FFS impact by those that paid for the FFS. The investment in training is usually expected to produce some political good will, but moreover, should increase economic benefits to the farmer and community, and eventually the nation. The major factors to be measured are inputs such as pesticides, time and labor, fertilizer, water use and equipment. Other benefits should also be considered such as higher rice prices for low or no spray crops that may be obtained with special labeling or improved soil fertility in cases where organic material is built up in the soil using IPM methods (green manure or compost). Such economic evaluations could be done on a seasonal or annual basis with IPM trained farmers to see long term impact.

Environment and health benefits may accrue with implementation of IPM. Fewer pesticides and less toxic pesticides use is a common outcome of beginning field observation and IPM methods. Measuring these benefits is not easy; however, a few indicators may be used. For environment, the occurrence of more natural enemies, or other wild life may be considered.

For health, immediate benefits can be measured by counting such indicators as lost work days, stomachaches, headaches, visits to local clinics for post-pesticide treatment ills, and other common illness related to pesticide exposure. A baseline should be made be measures before training at one season or more. It is important to separate crops: some farmers continue to spray heavily on some crops while reducing sprays.

Community Organization and Self-Funding can also be evaluated, and is one of the important goals of organizing the FFS through SLTP. Community organizations may continue to pursue IPM activities, but if the FFS group gets organized to take on other issues, like setting up of bio control lab through self funding, then the impact of the FFS will be much greater

(Annexure-I)

Requirements of essential stationery and field materials for SLTP

Sl.No.	Materials	Quantity
1	Colour chart papers	100
2	White news paper print roll	10
3	File covers	100
4	File tag(Bundles)	10
5	Xerox paper	10 bundles
6	Permanent marker pens	50
7	Sketch pen sets	20
8	OHP sheets	50
9	Foot scale	10
10	Micro tip pens	10
11	Punching machines	6
12	Staplers	6
13	Stamp pad	2
14	Cello tapes	12
15	Small thread balls	6
16	Needles	10
17	Scribbling pads	60
18	Ball pens	30
19	Fevisticks	10
20	Gum bottles	6
21	Plastic pouches	10
22	Rubber band bundles	10
23	Medium cotton rolls	10
24	Gem clip boxes	6
25	Drawing pin boxes	6
26	Colour film rolls	6
27	Chloroform 500 ml	6
28	Mosquito net cloth	20 meters. 29
29	Thermocol sheets	10
30	Bamboo sticks	200

(Annexure-II)

Allocation of additional duties and responsibilities to resource persons

Sl. No	Designation	Additional duties
1	General coordinator	Providing transport to entire training activities Reception and introduction of floating resource persons Bill settlement and correspondence
2	Technical coordinator	Providing information on every day field activities Procurement, supply and mobilization of every day field materials to trainees and resource persons
3	Resource persons-!	Looking after accommodation, food and refreshment Timely supply of food and refreshment
4	Resource person-II	Taking care of class room facilities Arrangement of audio visual aids Daily attendance Duplication of training materials and distribution
5	Resource person-III	Recording daily training activities and submitting reports to General co-coordinator Co-coordinating with inauguration and valedictory committee
6	Resource person IV	Providing medical and recreation facilities Arrangements for photos. Video coverage of training activities
7	Resource person V	Providing reception and accommodation to floating resource persons Attending to emergency activities arising during the training programme

*Supporting staff will assist the resource persons.

(Annexure-III)

Profile /Bio data of Participants

Name	
Date of birth	
Qualifications	
Experience	
Present official address	
Phone number and address of participant controlling offer	
Home address	
Address and phone number of person to be contacted in the event of emergency	
Place: Date:	Signature with date

(Annexure-IV)

Attendance sheet for participants

Date:

Sl.No	Name	Signature with date

Counter signed: General Co-ordinator

(Annexure-V)

Attendance sheet for Resource persons

Sl.No	Name	Signature with date

Counter signed: General Co-ordinator

Attendance sheet for supporting staff

Annexure VI

Sl.No	Name	Signature with date

Counter signed: General Co-ordinator

(Annexure-VII)

Certificate for participants

Certificate Model

Government emblem

Certificate

This is to certify that Shri/Smt…… …….. has successfully completed the season long training programme in Cotton IPM progamme held at ---------- --------- --------- --------- --------- ---------- from --------- ---------- to ---------- ----------

Plant Protection Advisor
Government of India

Director of Agriculture
Government of ----------

….(Annexure-VIII)

Certificate Model

Certificate for Resource person

Government emblem

Certificate

Shri/Smt…… …… …… …… …….. has participated has resource person in the season long training programme in Cotton IPM progamme held at ---------- from---------- --------- to ---------- ---------- ----------

Plant Protection Advisor
Government of India

Director of Agriculture
Government of ----------

(Annexure- IX)

Certificate for Farmer for attending to FFS

Farmers field school Certificate (in local language)

This is to certify that Shri/smt.----------
Son/daughter of --------- --------- ---------- ---------
Participated in the Farmers field school programme conducted during ---------- at ---------- village organized by----------

Astt. Director of Agri.
Government of ----------

Assistant Director/
Plant Protection Officer
CIPMC ----------

Base line survey format for FFS

Crop Season Year

Sl.No	Particulars
1	Name of the Farmer & Contact Number
2	Village :____Block:____ District:_____
3	Farm Area (In Hectares) Type of soil
4	Type of Irrigation:___ Crop & variety:_____
5	Gross yield for 1 hectare (last cropping season) (in Kgs.)
6	Key Insect pests observed during last season
7	Minor insect pests observed during last season
8	Major Diseases observed during last season
9	Known natural enemies of crop
10	Cultural pest control practices adopted
11	Major pesticides used & against pests
12	Type of sprayer used
13	Size of sprayer(in litres) used
14	Any Bio-pesticide/Botanical spray used
15	Number of tank loads used per hectare
16	Number of spraying operations per cropping season
17	Granular pesticides used (Kg/ha)
18	Wettable powders used (Kg/ha.)
19	Seed rate used per ha
20	Do you use cocktail type of pesticide
21	Cost of seeds used per ha.
22	Cost of seedbed preparation
23	Cost of land preparation per ha.
24	Cost of transplanting per hectare
25	Irrigation cost per hectare per cropping season
26	Labour costs for hand weeding/spraying of herbicide/day/hectare
27	Interest for crop loan/hectare
28	Fertilizer used No. of bags Cost of one bag Total cost
29	Labour cost for application of fertilizer /hectare
30	No. & cost of liquid pesticide (EC) used/ hectare
31	No. & cost of wettable powder used / hectare
32	No. & cost of granular pesticides used/ hectare
33	Labour cost for spraying of pesticides
34	Any other expenses incurred for plant protection measures
35	Rate of produce sold (price
36	Yield obtained
37	Profit (last season)

Signature FFS in charge

Season Long Training Programme

Table of contents

Chapter-II

Conservation & Augmentation of Bio-control Agents

CONSERVATION & AUGMENTATION OF BIO-CONTROL AGENTS

Introduction: Eco-system consists of both biotic and abiotic factors which contribute to sustain the ecosystem. The optimum abiotic conditions help to survive the biotic fauna and flora in proper way in the ecosystem. Slight or extreme variations in the abiotic conditions lead adverse effect on the survival of existing flora and fauna of an ecosystem. Both natural and manmade interference in the ecosystem also put adverse impact on biotic components of ecosystem. Hence, for the better survival of flora and fauna it is very essential to maintain the abiotic and biotic factors better suited for their survival. Keeping in the view the above facts, the conservation of bio-control agents can be defined as follows-

"To make environment better suited for bio-control agents or natural enemies of crop pests and weeds is called as conservation of bio-control agents"

"The removal of those cultural practices which are harmful for the buildup of natural enemies of crop pests and weeds (bio-control agents) is called as conservation of bio-control agents"

"To preserve, Protect and Promote the abundance of organisms that may keep the abundance of harmful organisms (pests) under check."

In ecosystem both biotic and abiotic factors are interdependent on each other even different biotic factors *i.e* fauna and flora are interdependent on each other. They also have competition among themselves in form of antibiosis and symbiosis. Parasitism, predation and hyper-parasitism are the means of their dependency hence, for the survival and conservation of bio-control agents there has to be safety devices from their hyper parasitoids or predators. A parasitoid and predator must be host specific as extent as possible and should not be affected with their hyper parasitoids prevailing in that particular area. Keeping in the view the above we must manipulate the habitat of bio-control agents through different means for the conservation of bio-control agents.

Crop plants and their pests or crop pests and their natural enemies have adapted to each other over time in a process called **co-evolution**. The genetic diversity evolved by pests and their natural enemies through co-evolution is particularly complex because both are genetically variable over time and space, which eventually resulted into unsuccessful innundative or inoculative augmentation processes. The conservation of natural enemies including agro biodiversity in a small area within local environments help to ensure that the ongoing processes of evolution and adaptation of those beneficial insect pests to their environments are maintained within farming systems. This benefit is central to *in situ* conservation, as it is helpful as reservoir for further augmentation of already adapted parasite, predators and entomo-pathogens over rest the field afterwards.

Programmes to be implemented for the Conservation & Augmentation of bio-control agents:

1. Conducting fixed plot surveys through FFS to note the seasonal build up of pests & defenders (bio-control agents).
2. Conducting trials for ecological engineering and habitat manipulation
3. Installation of conservation devices through conservation cages, bamboo cage, bird pearcher etc.

4. Wide publicity through hoarding, audio visuals etc.
5. Farmers education & HRD through Participatory Action Research (PAR) activities like field exercises on different aspects, insect zoo etc.
6. Conducting AESA in FFS fields.
7. Development & Strengthening of bio-control labs through Self Help Groups (SHG)
8. Capacity building of staff

Tools for conservation & augmentation of bio-control agents:

1. List of prevailing bio-control agents in a particular area
2. Albums for visual identification of bio control agents, diseases and weeds
3. Preparation of insect zoo
4. Conservation devices like conservation cages, bamboo preacher, bird preachers etc.
5. To maintain *in-situ* bio-agent sanctuary by CIPMCs
6. Formats for observations

Items required for conservation & augmentation kit:

1. Vehicle (4 wheel drive) with driver
2. Survey route map
3. Survey Performa
4. Pen or pencil, Eraser, Sharpener
5. Writing pad
6. GPS enabled Data logger
7. Collection vials with lid
8. Cotton
9. Rubber bands
10. Brush
11. Needle
12. Thread
13. Polythene bags
14. Aspirator
15. Sweeping / butterfly net
16. Watch glass
17. Hand lenses of different capacity
18. Chloroform
19. Killing bottle
20. Pruning knife
21. Spade
22. Khurpi
23. Mt. square/Quadrant
24. Kit bag
25. Hand Gloves
26. Gum boots/sleeper
27. Forceps
28. Scissors
29. Cloth
30. Muslin cloth
31. Field cap
32. Rain coat/Umbrella
33. Stapler with pins
34. Blotting paper
35. Herbarium press
36. Entomological pins
37. Plastic/polythene bags
38. Paper soap/liquid soap
39. Torch with cell
40. First aid box with medicine
41. Blade
42. Drawing sheets
43. Sketch pens
44. Field camera
45. Mobile phone
46. Water bottle
47. Stick
48. Half pant
49. Field Apron/T-shirt
50. Measuring tape
51. Tags/Labels

Some pests and their common natural enemies

PESTS	NATURAL ENEMIES					
	Lacewings	Lady bird beetles	Parasitic flies	Parasitic wasps	Predatory mites	**Other groups and examples**
aphids	•	•		•		entomopathogenic fungi syrphid fly larvae
caterpillars	•		•	•		*Bacillus thuringiensis* birds, pathogenic fungi and viruses, predaceous wasps, *Trichogramma* spp., spiders, predacious bugs.
cottony cushion		•	•			vedalia beetle
whitefly	•	•		•	•	Coccinellid beetls
lace bugs	•	•		•		pirate bugs spiders
mealy bugs	•	•		•	•	mealybug destroyer lady beetle
psyllids	•	•		•		pirate bugs
scales	•	•		•	•	*Aphytis* spp. (armored scale parasites)

slugs, snails			•			predaceous ground beetles vertebrates
spider mites	•	•			•	sixspotted thrips *Stethorus* sp. (spider mite destroyer lady beetle)
thrips	•				•	predatory thrips
weevils, root or soil-dwelling						*Steinernema carpocapsae* and *Hetero rhabditis bacteriophora*(entomopathogenic nematodes), soil dwelling predatory beetles and other predators.

*

http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn74140.html

Ways and Means of Conservation of Natural Enemies of Crop pests

1. Avoiding blanked sprays of Pesticides and adopting spot application as a last resort.
2. Replacing chemical pesticides with bio-pesticides.
3. Growing of Trap crops (attractant crops for natural enemies) and flowering plants like dill, anise, spear mint, buck wheat, yarrow, white clover, tansy, cow pea, fennel, cosmos etc.
4. Intercropping with nectar rich plants like caraway, coriander, sunflower, parsley (ajwain), mustard, marigold, carrot, alfalfa, corn flowering/push-pull plants.
5. Installation of conservation cages or bamboo cages.
6. By growing the crops that provide Pollen and Honey dew to the natural enemies.
7. Augmenting the population from areas of abundance to the areas of absence.
8. Avoiding the trash burning where the abundance of Natural enemies is found.
9. By releasing proper strains of natural enemies timed with proper pest stage.
10. Promoting Non-chemical methods of Pest Management like bio-pesticides
11. Keeping a regular and strict surveillance Programme to note the buildup of population of Crop pests and their natural enemies.
12. By educating the Farmers 'How to conserve the natural enemies in their crop fields' by way of demonstration.
13. By adopting P: D ratio and AESA.
14. Reduce the use of broad spectrum persistent pesticides where ever possible. Use reduced risk pesticides. Avoid use of neonicotinoids and other chemicals which are highly/moderately toxic to honey bees in crops pollinated by honey bees.
15. Certain weeds in rice environment are infested with insects that alternatively support rice pest parasitoids in off-season. *Nanophyes* sp. on *Ammania baccifera* L. a weed in rice fields have been identified as a reservoir host supporting parasitoids like *Neanastatus cinctiventris* Girault on gall midge, *Trichomalopsis* sp. on *Pelopidas mathias* (Fabr.).

Ammania baccifera

16. Intercropping of crop plants like mustard and linseed (alsi) etc. provide nectar to the parasitoids and support their population.
17. Efforts to educate farmers in recognizing natural enemies and the beneficial role played by them are important as the role played by the parasitoids remain unnoticed. Utilization conservation of natural enemies in situ in the rice ecology is the most practical option available for promotion of natural bio-control.
18. Birds are the efficient predators of various insect pests. Efforts should be done to educate farmers about the role of predatory bird and their need in crop ecosystem.
19. Conserve spiders in field

Conserve and Augment the following BC Agents

Name of BC Agents	Ways & Means of conservation
Bracon sp.	Braconides feed on honey dew, nectar or pollen; hence, the flower plants like Dill, Parsiety, Zinnia, Clover, Aalfa-alfa, Cosmos, and Sunflower may be grown on border or as intercrops to attract the native Braconides population.
Cotesia sp.	By planting above flowering herbs
Trichogramma	Releases may be timed with presence of host egg stage in the field -Suitable strains must be release. -Continue the releases till the natural breeding is established.
Epiricania melanoliuca	-Strict surveillance programme may be put in operation. - Avoid indiscriminate trash burning. -Augmenting in new area. -Avoiding Aerial spray of pesticides.
Damsel bug (*Nevid* sp.)	-Collect from the areas of high abundance and release them to the areas of absence.
Damsel and Dragon fly	Larvae found in water. Maintain watery condition around field by making a water channel.
Ground beetle (*Ophionia*)/ Rove beetle/carabid beetle	Strip mulching provides permanent pest and perennial planting. -Plant white clover or *Amaranths sp.* as ground cover.
Rove beetles (*Staphylinid beetles*) and Ground Beetles(*Carabid beetles*)	* Conserve or develop refuges for soil dwelling rove beetles. This could be done by promoting plant diversity, using mulches and keeping stones, logs or other items that provide protection.
Green lace wing (*Chrysoperla* sp.)	Plant flowering plants such as Dill, Parsiety, Zinnia, Clover, Aalfa-alfa, Cosmos, Sunflower, Carrot, Dandelion as they are good source of pollen and Nectar for adults. Provide the source of water during dry season. Maintain perennial plant like mango, Litchi etc.
Lacewings	*Make sure flowers (e.g. dill, sunflower, carrots) are present in the field or close to the crop to ensure food supply for adult lacewings. Populations can be maintained on a non-pest aphid species and other hosts outside crop area (in weedy areas on field margins).
Lady bird beetle	Avoid indiscriminate use of pesticides. Grow fodder crops like Barseem. Collect from the plants like Calotropis and release them in desired fields. *Ladybirds can be encouraged by growing non-crop plants which support aphid species which do not attack crops. Grow strips or groups of non-crop flowering plants such as fennel, thistles, coriander, carrots and/or milkweed. They can also be brought in by hand from outside the crop. Spraying with pesticides should be avoided wherever possible in order not to kill the ladybird adults and larvae but if it is necessary, selective pesticides and methods should be used.
Spider	Mulching in strips. Avoid indiscriminate use of pesticides.
Hover-flies	*Hover flies can be encouraged by allowing non-crop plants to grow around fields - these support non-pest species of aphids that hover fly larvae can feed on. They are attracted to all flowering plants but especially to fennel, milkweed, sun hemp, flowering brassicas or wild mustard, thistles, sunflower, coriander and dill. In rape and kale, some of the previous crop can be left to flower (provided the pest and disease levels are low) or a small number of plants from the current crop can be encouraged to bolt and flower by stopping watering. Avoid spraying with pesticides whenever possible but if it is necessary, use selective

	pesticides and methods.
Predatory Ants	* Excessive hoeing or ploughing will destroy ant nests so farming systems which use minimum tillage (very little hoeing or ploughing) are more likely to encourage beneficial ants.
Predatory thrips	*Avoid use of broad spectrum pesticides.
Parasitic flies	*Provide sugar containing food sources for the adult such as flowers or honeydew. Encourage habitat diversity. Avoid spraying pesticides. When necessary select a product and application method that is less harmful to natural enemies.

*Source: www.infonet-biovision.org

BIO-CONTROL AGENTS OF DIFFERENT CORPS

Sl. No.	Name of Bio-Control Agents	Crops	Pests
1.	*Trichogramma chilonis* Cotton Strain	Cotton	Bollworms
2.	*Trichogramma chilonis* Sugarcane Strain	Sugarcane / Rice	Borers
3.	*Trichogramma exiguum*	Sugarcane	Borers
4.	*T. minutum*	Sugarcane	Borers
5.	*T. perkinsi*	Sugarcane	Borers
6.	*T. faciatum*	Sugarcane	Borers
7.	*T. brasilienses*	Cotton	Bollworm
8.	*T. pretiosum*	Cotton	Bollworm
9.	*T. embriophagum*	Apple	Codling moth
10.	*T. coccai palladium*	Apple	Codling moth
11.	*Trichogramma toidea spp.*	Rice/ vegetable	Borers
12.	*Bracon hebetor*	Cotton/ gram/ vegetable	Bollworm/ Pod borer/ fruit borer
13.	*Bracon brevicornis*	Cotton/ gram/ vegetable	Bollworm / Pod borer / fruit borer
14.	*Bracon kirkpatricki*	Cotton / gram / vegetable	Bollworm / Pod borer / fruit borer
15.	*Chelonus blackburni*	Cotton / gram / vegetable	Bollworm / Pod borer / fruit borer
16.	*Chelonus kelliae*	Potato	Potato tuber moth
17.	*Telenemus remus*	Cotton/soya bean	*Spodeptera litura*
18.	*Apantelese flavipes*	Maize	Stem borer
19.	*Sticholotis madagassa*	Sugarcane	Scale insect
20.	*Lindorus lophanthae*	Sugarcane	Scale insect
21.	*Chilocorus bijugus*	Apple / Citrus	Scale insect
22.	*Pharoscymnus perniciosi*	Apple / Citrus	Scale insect
23.	*Iceriya purchasii*	Citrus	Scale insect
24.	*Encarsia perniciosi*	Apple	Scale insect
25.	*Encarsia spp.*	Fruit / vegetable	White Fly
26.	*Aphytis spp.*	Apple	Scale insect
27.	*Pharoscymnus horni*	Sugarcane	Scale insect
28.	*Aphidius spp.*	Mustard	Aphid
29.	*Amblysius spp.*	Cotton / apple	Mite
30.	*Aphelinus mali*	Apple	Woolly aphis *(Eriosoma lanigerum)*
31.	*Neochetina eichhornai*	Water hyacinth Weed	Weed
32.	*Neochetina bruchi*	Water hyacinth Weed	Weed
33.	*Zygogramma bicolorata*	Parthenium weed	Weed
34.	*DD-136 nematode Neo-aplectana carpocapsae*	Rice	Borer
35.	*Paratheresia claripalpis*	Sugarcane	Borer
36.	*Eucelatoria bryani*	Gram	*H. armigera*
37.	*Chrysoperla scelestes*	Cotton	Sucking pest / bollworm
38.	*Chrysoperla carnia*	Cotton	Sucking pest / bollworm
39.	*NPV of H.*	Cotton /	*H.*

	armigera	Gram/ Vegetable	*armigera*
40.	*NPV of spodoptera litura*	Cotton/ Soyabean/ vegetable	*Spodoptera litura*
41.	*Sturmiopsis*	Sugarcane/ tomato / rice	Borers
42.	*Tetrastichus spp.*	Rice	Borers
43.	*Goniozus spp.*	Rice	Leaf folder
44.	*Cryptolemus spp.*	Grape vein/ citrus / coffee	Mealy bug
45.	*Scymnus spp.*	Grape vein/ citrus / coffee	Mealy bug

Natural enemies of crop pests in India

Parasitoids

HYMENOPTERA

- *Acerophagus papayae* Noyes & Schauff
- *Aenasius advena* Compere
- *Aenasius bambawalei* Hayat
- *Aenasius indicus* (Narayanan & Subba Rao)
- *Allotropa* sp.
- *Amitus* spp.
- *Anagyrus agraensis* Saraswat
- *Anagyrus loecki* Noyes & Menezes
- *Anicetus ceroplastodis* (Mani)
- *Aphanogmus fijiensis* (Ferriere)
- *Apenesia sahyadrica* Azevedo & Waichert
- *Blepyrus insularis* (Cameron)
- *Bolangera sankarani* Hayat & Noyes
- *Bracon brevicornis* (Wesmael)
- *Bracon hebetor* (Say)
- *Brachymeria nephantidis* Gahan
- *Callaspidia notata* (Boyer de Fonscolombe)
- *Campoletis chlorideae* Uchida
- *Cephaleta australiensis* Howard
- *Cephaleta brunniventris* Motschulsky
- *Charops bicolor* (Szepligeti)
- *Chelonus blackburni* Cameron
- *Comperiella indica* Ayyar
- *Coccidoxenoides perminutus* Girault
- *Coccophagus ceroplastae* (Howard)
- *Coccophagus pseudococci* Compere
- *Cotesia flavipes* (Cameron)
- *Cotesia vestalis* Haliday
- *Diaeretiella rapae* (Mc'Intosh)
- *Diplazon laetatorius* (Fabricius)
- *Dirhinus anthracia* Walker
- *Distatrix papilionis* (Viereck)
- *Elasmus* spp.
- *Encarsia guadeloupae* Viggiani
- *Encyrtus aurantii* (Geoffroy)
- *Eriborus argenteopilosus (*Cameron)
- *Exoristobia philippinensis* Ashmead
- *Goniozus nephantidis* (Muesebeck)
- *Gryon fulviventre* (Crawford)
- *Ischnojoppa luteator* (Fabricius)
- *Isotima javensis* (Rohwer)
- *Leptomastix dactylopii* (Howard)
- *Marietta leopardina* Motschulsky
- *Megastigmus viggianii* Narendran & Sureshan
- *Meteoridea hutsoni* (Nixon)
- *Neocharitopus orientalis* (Agarwal)
- *Neodusmetia sangwani* (Subba Rao)
- *Nesolynx thymus* (Girault)
- *Oomyzus sokolowskii* (Kurdjumov)
- *Plagiomerus bangaloriensis* Shafee *et al.*
- *Podagrion* spp.
- *Praleurocerus viridis* (Agarwal)
- *Prochiloneurus aegyptiacus* (Mercet)
- *Prochiloneurus albifuniculus* Hayat *et al.*
- *Prochiloneurus pulchellus* Silvestri
- *Promuscidea unfasciativentris* Girault
- *Pseudleptomastix mexicana* Noyes & Schauff
- *Quadrastichus mendeli* Kim & La Salle
- *Scutellista caerulea* (Fonscolombe)
- *Stenobracon deesae* (Cameron)
- *Stenobracon nicevillei* (Bingham)
- *Tetrastichus howardii* (Olliff)
- *Tetrastichus schoenobii* Ferriere
- *Theocolax elegans* (Westwood)
- Trichogrammatids
- *Trichopria* sp.
- *Xanthopimpla stemmator* (Thunberg)

LEPIDOPTERA

- *Epiricania melanoleuca* (Fletcher)

DIPTERA

- *Halidaia luteicornis* (Walker)
- *Peribaea orbata* (Wiedemann)

Insect Predators

COLEOPTERA: COCCINELLIDAE

- *Anegleis cardoni* (Weise)
- *Axinoscymnus puttarudriahi* Kapur & Munshi
- *Brumoides suturalis* (Fabricius)
- *Coelophora bissellata* Mulsant
- *Chilocorus circumdatus* (Gyllenhal)
- *Chilocorus nigrita* (Fabricius)
- *Cheilomenes sexmaculata* (Fabricius)
- *Coccinella transversalis* Fabricius
- *Coccinella septempunctata* Linnaeus
- *Cryptolaemus montrouzieri* Mulsant
- *Curinus coeruleus* (Mulsant)
- *Harmonia dimidiata* (Fabricius)
- *Harmonia eucharis* (Mulsant)
- *Harmonia octomaculata* (Fabricius)
- *Hippodamia variegata* (Goeze)
- *Hyperaspis maindroni* Sicard

- *Illeis cincta* (Fabricius)
- *Megalocaria dilatata* (Fabricius)
- *Nephus regularis* Sicard
- *Pharoscymnus flexibilis* (Mulsant)
- *Pharoscymnus horni* (Weise)
- *Rodolia amabilis* Kapur
- *Rodolia fumida* (Mulsant)
- *Scymnus castaneus* Sicard
- *Scymnus coccivora* Ramakrishna Ayyar
- *Scymnus nubilus* Mulsant
- *Scymnus latemaculatus* Motschulsky
- *Serangium parcesetosum* Sicard
- *Synonycha grandis* (Thunberg)

COLEOPTERA: NITIDULIDAE

- *Cybocephalus* spp.

COLEOPTERA: STAPHYLINIDAE

- *Oligota* sp.
- *Paederus fuscipes* Curtis

NEUROPTERA: CHRYSOPIDAE

- Chrysopids

NEUROPTERA: HEMEROBIIDAE

- *Micromus igorotus* Banks
- *Micromus timidus* Hagen

HEMIPTERA: ANTHOCORIDAE

- *Blaptostethus pallescens* Buchanan-White
- *Cardiastethus exiguus* Poppius
- *Orius tantillus* (Motschulsky)
- *Xylocoris flavipes* (Reuter)

HEMIPTERA: LYGAEIDAE

- *Geocoris* sp.

HEMIPTERA: PENTATOMIDAE

- *Andrallus spinidens* (F.)

HEMIPTERA: REDUVIIDAE

- *Isyndus heros* (F.)

DIPTERA: CHAMAEMYIIDAE

- *Leucopis* sp.

DIPTERA: CRYPTOCHAETIDAE

- *Cryptochaetum* sp.

DIPTERA: DROSOPHILIDAE

- *Acletoxenus* sp. nr. *indicus* Malloch
- *Cacoxenus (Gitonides) perspicax* (Knab)

DIPTERA: SYRPHIDAE

- *Dideopsis aegrota* (Fabricius)
- *Ischiodon scutellaris* (Fabricius)
- *Paragus serratus* (F.)
- *Paragus yerburiensis* Stuckenberg
- *Episyrphus balteatus* (F.)
- *Eupeodes confrater* (F.)

LEPIDOPTERA: NOCTUIDAE

- *Coccidiphaga scitula* (Rambur)

LEPIDOPTERA: LYCAENIDAE

- *Spalgis epeus* (Westwood)

LEPIDOPTERA: PYRALIDAE

- *Dipha aphidivora* (Meyrick)

THYSANOPTERA: THRIPIDAE

- *Franklinothrips vespiformis* Crawford

Weed insects

- *Cecidochares connexa* Mcquart
- *Cyrtobagous salviniae* Calder & Sands
- *Neochetina eichhorniae* Warner
- *Neochetina bruchi* Hustache
- *Orthogalumna terebrantis* Wallwork
- *Pareuchaetes pseudoinsulata* (Rego-Barros)
- *Teleonemia scrupulosa* Stal
- *Zygogramma bicolorata* Pallister

Invasive pests

- *Hypothenemus hampei* Ferrari
- *Leptocybe invasa* Kim & La Salle
- *Paracoccus marginatus* Williams & Granara de Willink
- *Phenacoccus solenopsis* Tinsley
- *Quadrastichus erythrinae* Kim

Potential Invasives

- *Brontispa longissima* Gestro

(Source: National Bureau of Agriculturally Important Insect, Bangalore)

Ecological Engineering for conservation of Bio-control agents

To make the environment better suited for the buildup of existing beneficial fauna through manipulation of biotic and abiotic factors of ecosystem is called ecological engineering.

Ecological engineering for conservation of bio-control agents is manipulation of the habitat in the crop ecosystem for buildup of beneficial bio-control agent.

Ecological engineering is based on ecological principles in which the environment of Agro-eco-system is made suitable for the better survival of bio-control agents/beneficial fauna. It's a kind of human intervention to manipulate the habitat better suited for the buildup of bio-control agents.

For the better survival and build up of bio-control agents in Agro-eco-system, the following things are required:

1. Food in form of pollen and nectar for adult bio-control agents.
2. Shelters such as overwintering sites, moderate microclimate, etc.
3. Alternate hosts are required when primary hosts are not present.

The knowledge about the following is required for the habitat manipulation of pests and their Natural Enemies:

1. Food and habitat of the pests
2. Factors affecting the growth of pest build up.

3. The time of infestation on crop by the pests and the time of development/ build up of bio-control agents for the pest in the crop.
4. The pattern of the development of the pests and the level of causing economic damage.
5. The parasitoids, predators and pathogens of the particular crop pests.

Ecological Engineering for pest management- Above ground:

To fulfill the above requirement for habitat manipulation for making environment suitable for multiplication of beneficial fauna in an agro eco system, the inter-cropping, border-cropping and mix cropping of the flowering plants is required which provide nectar/ pollen as food for various bio-control agents and other beneficial fauna. Growing of alternate crops as a food for pests required for survival of beneficial fauna is another way of conservation and habitat manipulation. The trap crops and repelling crops for pests are also grown as intercrop along with the main crop.

The following flowering crops are generally grown as trap/attractant under agro-ecological engineering:

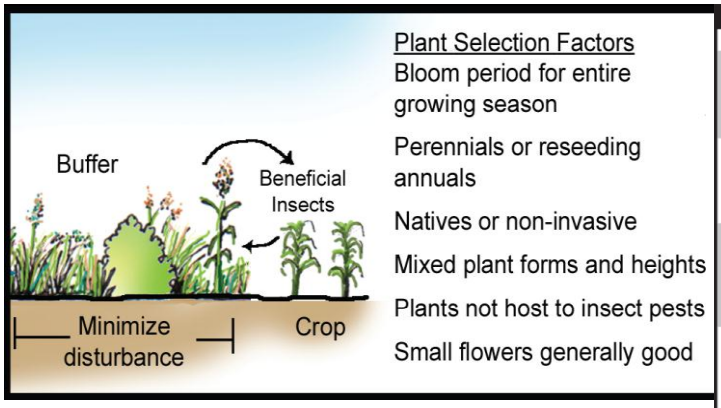
Cosmos, Sunflower, Okra, Hibiscus, Marigold, Fennel, Onion, Carrot, Coriender, Sesame, *Chrysanthemum*, Tridax, Mustard, Radish, *Fagopurum*, Ageratum, *Alternanthera* sp., Alfalfa etc.

Ecological Engineering for pest management- Below ground:

- Crop rotations with leguminous plants.
- Keeping soils covered with vegetation and/or crop residue.
- Adding organic matter in the form of FYM, vermi-compost, crop residue
- Reducing tillage intensity so that hibernating natural enemies can be saved.
- Apply bio-fertilizers producing bio-agents.
- Apply *Mycorrhiza* and Plant Growth Promoting Rhizobium (PGPR).
- Apply *Trichoderma* and *Pseudomonas fluorescence* as seed, nursery treatment and soil application (if commercial products are used, check for label claim), However, bio-pesticides produced by farmers for own consumption in their fields, registration is not required.

Photographs of Ecological engineering Demo Field

Above mentioned photographs are sowing the demonstration of Ecological Engineering in cole crops conducted by the Directorate of plant protection, Quarantine & Storage during Krishi Vasant 2014 held from 09-13 Feb, 2014 at CICR Nagpur. In this photograph the Cole crops were bordered by the Sunflower, Mustard, Marigold and Coriander crops. The Sunflower was the tallest crop to attract the Helicoverpa pest; it was surrounded by the two rows of mustard to attract Chrysoperla and LBB. Coriander was an excellent crop for attract different natural enemies of main crop pets. Marigold crop was preferable crop for egg laying of Helicoverpa. It was observed that the cabbage and cauliflower crops found affected with aphid and the aphid population on Cole crops was found parasitized by *Aphidius*, a potential parasite of aphid. This parasite could be able to manage the aphid population on Cole crops.



Plants that Attract Beneficial Insects

Beneficial	Pests	Plants/Habitat
Assassin bug (Reduviidae family)	Many insects including flies and large caterpillars	Permanent plantings for shelter (e.g., windbreaks)
Bees-Butterflies (Many families)	None but important for pollination	Pea, borage, and aster families, milkweeds, butterfly bush, others
Braconid wasp (Braconidae family)	Armyworm, cabbageworm, codling moth, gypsy moth, European corn borer, aphid, caterpillars, and other insects	Nectar plants with small flowers, yarrow, sunflower, cowparsnip
Damsel bug (Nabidae family)	Aphid, thrips, leafhopper, treehopper, caterpillars	Aster family, yarrow, common boneset
Ground beetle (Carabidae family)	Slug, snail, cutworm, Colorado potato beetle, gypsy moth, caterpillars, weed seeds	Amaranth, bunch grasses, permanent plantings for shelter

Plants that Attract Beneficial Insects

Beneficial	Pests	Plants/Habitat
Hover fly (Syrphidae family)	Aphid	Carrot and aster family (coreopsis, sunflowers, goldenrod), cowparsnip, common boneset
Lacewing (Chrysopidae family)	Soft bodied insects including aphid, thrips, European corn borer, mealybug, scale, mite	Carrot and aster family (coreopsis, sunflowers, goldenrod)
Ladybug beetle (Coccinellidae family)	Aphid, spider mite, European corn borer, mealybug	Aster family, butterfly weed, native grasses, giant hyssop, cowparsnip, yarrow, black locust
Minute Pirate Bug (Anthocorid family)	Thrips, spider mite, leafhopper, corn earworm, small caterpillars, and other insects	Carrot and aster family (daisies, sunflowers, yarrow, goldenrod), blue elderberry, potentilla, giant hyssop, common boneset, and willows
Rove beetle (Staphylinidae family)	Aphid, nematode, flies	Native grasses, permanent plantings for shelter
Spider (Salticidae, Thomisidae, and other families)	Many insects	Carrot and aster family, giant hyssop
Spined soldier bug (*Podisus maculiventris*)	Armyworm, sawfly, Colorado potato beetle, Mexican bean beetle	Aster family (sunflowers, yarrow)
Tachinid fly (Tachinidae family)	Cutworm, armyworm, May beetle, gypsy moth, squash bug	Carrot and aster family, amaranth
Tiger beetle (Cicindelidae family)	Many insects	Amaranth, bunch grasses, permanent plantings for shelter
Chalcid wasps (many families including Trichogrammatidae)	Spruce budworm, cotton bollworm, tomato hornworm, corn earworm, corn borer, codling moth	Carrot and aster family (daisies, sunflowers, yarrow, goldenrod), potentilla, giant hyssop, cowparsnip, common boneset

Recognizing Natural Enemies

Proper identification of pests, and distinguishing pests from their natural enemies, are essential to effectively using biological control. Pocket books, charts, albums, specimen boxes and live samples of crop specific pest & predators should be prepared and they should be displayed among farmers and extension officials so that one can easily recognize natural enemies.

Encourage these natural enemies by avoiding pesticides that kill them; choosing plants that provide them pollen, nectar, and shelter; and keeping ants out of pest-infested plants. Common predators that eat garden pests are pictured below with bars showing their length.


Convergent lady beetle adults (left) and most reddish lady beetle species prefer aphids. Their **larvae** (right) prefer aphids but sometimes eat whiteflies and other soft-bodied insects.

Lady beetle eggs are oblong, widest in their middle, usually yellowish or orange, and can be laid in groups or individually.

Syrphid fly larvae eat mostly aphids but also soft-bodied mealybugs, psyllids, and whiteflies.


Green lacewing adults (left) eat nectar and pollen. Some species also eat insects. **Lacewing larvae** (right) feed on mites, eggs, and small insects, especially aphids.

Green lacewing eggs are laid on slender stalks in groups (as shown here) or individually, depending on the species.

Soldier beetle adults eat mostly aphids. Their soil-dwelling larvae eat beetle and moth eggs and larvae.


Predaceous ground beetle adults (left) stalk soil-dwelling insects, such as cutworms and root maggots. Their **larvae**(right) live on soil and in litter, feeding on almost any invertebrate.

Assassin bugs attack almost any insect.

Pirate bugs attack mites and any tiny insect, especially thrips.

Western predatory mitesattack pest mites.

Sixspotted thrips attack mostly mites.

Spiders, including this crab spider, attack all types of insects.

Praying mantids don't control pests, because they eat both beneficials and pests.

Adults of predatory wasps, such as this paper wasp, prey on caterpillars and other insects.

Syrphid fly (flower fly, hover fly) adults eat pollen and nectar and resemble honey bees and wasps. Adults act as good pollinator.

Source:www.ipm.ucdavis.edu

Cultural practices that affect natural enemies

Tillage

Tillage can have a major impact on soil organisms and on the relationships between organisms of different trophic levels. Tillage intensity, the method used, the frequency of tillage operations and the dates of crop planting and harvesting are all factors that can affect natural enemies. Generally, reduced tillage promotes a more stable environment, which in turn promotes a diversity of species. Less tillage is associated with greater abundance and diversity of the fauna. However, the effects vary from one species to another, depending on their specific ecological characteristics. For example, species with a soil-dwelling larval or pupal stage are particularly sensitive to tillage. A study carried out with canola demonstrated that post-harvest tillage led to a reduction the next spring in the rate of emergence of parasitoids overwintering in the soil.

Herbicides and pesticides use

Numerous studies have demonstrated the negative effects of pesticides on natural enemy communities. The effects on predators and parasitoids can be direct (e.g. direct effects on their biological functions) or indirect (e.g. effects on their secondary resources) may be noticed.

Nitrogen fertilization

In addition to having an effect on pests, fertilization can also impact their natural enemies.

Seeding and harvesting dates

Seeding and harvesting dates could have an impact on both pests and natural enemy communities. Harvesting constitutes a massive disturbance which may have a greater impact on spiders than pesticide use.

Practice IPM: Integrate the use of host-plant resistance, seed treatment, bio-pesticides, and green level pesticides to conserve natural enemies. Evaluate the potential for interference among control strategies and work towards ways that promote synergisms among the different aspects of crop production technology.

Wise use of Insecticides: Insecticides are generally non-selective and kills the insects uniformly. It is, therefore, desired to select proper insecticide wisely by applying mind and use that judicially.

Avoid indiscriminate trash burning: Indiscriminate trash burning should be avoided to conserve natural enemies of crop pests.

Screening of hibernating parasites: Screening of hibernating parasites in the cotton bolls etc. and release them in the field may be done.

Provide supplementary food: Provide supplementary food for the natural enemies or beneficial fauna like predatory ants. Spray dilutes sugar solution to provide food for the free living natural enemies adults.

Provide neutral organisms as food to avoid cannibalism among predators.

IDENTIFY THE BIO-CONTROL AGENTS

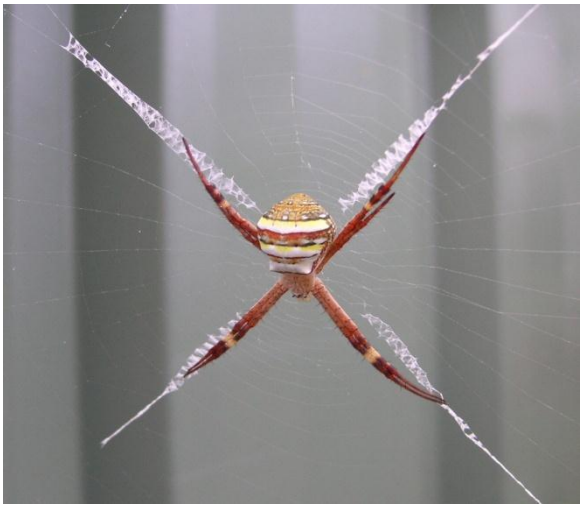
A. Spiders

Araneus mitificus

Thomisus sp.

Golden Orb Spider

Cyclosa insulana



Saint Andrews Cross

Cyclosa insulana

Chrysso argyrodiformis

Leucauge venusta

Lycosa

Widow spider

Lynx spider

Tetragnatha Spider

Oxypes

Crab Spider

Green orb spider

Water Spider

Goblin/Ant Spider

Lady bird beetle

Chrysoperla carnea

B. Insect Predators

Cicindela punctulata

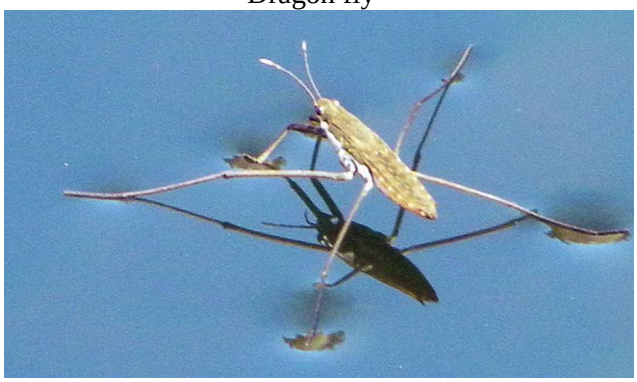
Bembidion quadrimaculat

Damsel fly

Cicindella spp.

Dragon fly

Geocoris tricolor



Water strider

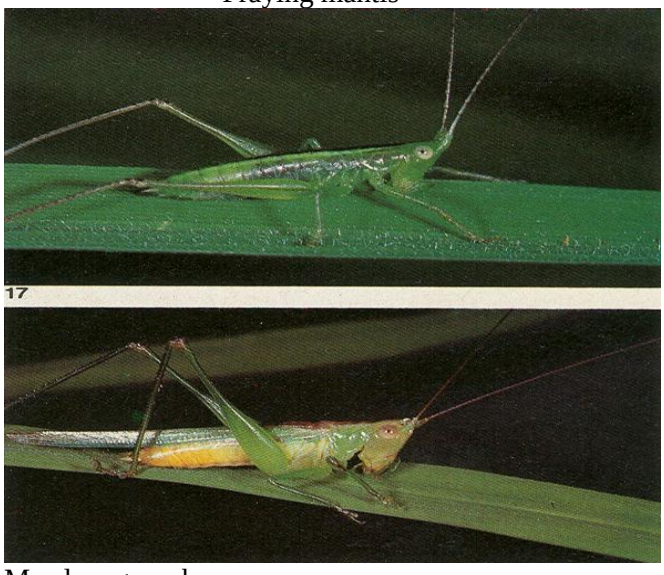
Assassin bugs (Reduvius sp.)

Xanthopimpla

Syrphid fly larvae

Anthocorid bug

Praying mantis



Meadow grass hopper

Cryptolaemus montruzieri grub & Adult

C. Parasitoids

Trichogramma sp.

Chelonus blackburni

Apanteles sp.

Bracon-hebetor

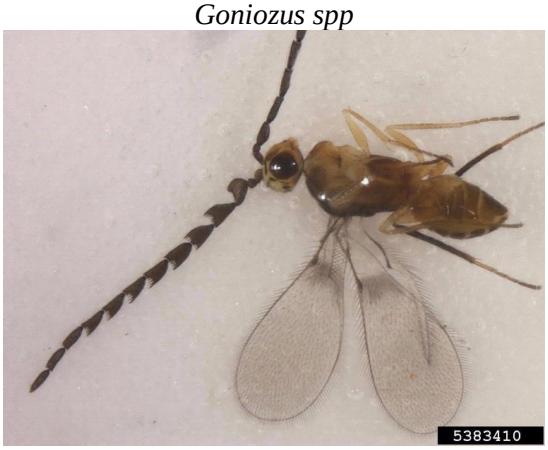
Tetrasticus

Epiricania melanoleuca

Brachymeria

Tachinid fly

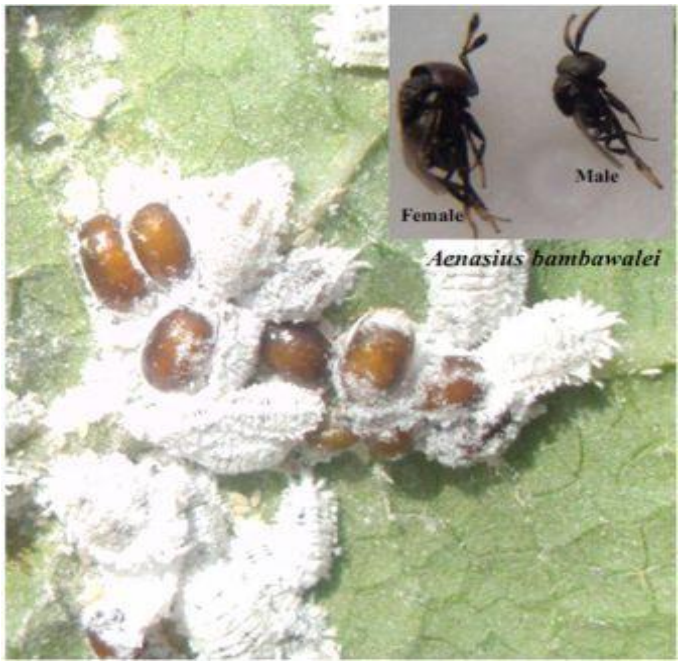
Goniozus spp



Gonatocerus spp.

Metopius sp.

Trichospilus pupivora



Aenasius bambawalei

D. Entomopathogens

Beauveria bassiana

Metarhizium anisopliae


NPV infected larvae

AUGMENTATION OF NATURAL ENEMIES

When resident natural enemies are insufficient, their populations can be increased (augmented) through the purchase/production and release of commercially available (laboratory breed) beneficial species. Releases are unlikely to provide satisfactory pest control in most situations. Some marketed natural enemies are not effective.

Two types of procedures are used to obtain reduction in pest population. These are:

1. **Innundative releases:** To saturate the area through the regular and mass release of laboratory breed bio-control agents to get quick control of the pest. The regular releases of the bio-control agents are made throughout the crop season at regular interval without seeing the broods of the pests. The effectiveness of the bio-control agents can be judged by seeing the direct and indirect recovery trials. As experienced the weekly release of *Trichogramma* sp. @ 20,000 adults or parasitized eggs per Acre per week throughout the crop season gives control of lepidopteron pests in Sugarcane, Cotton, Rice and vegetable crops. The release of *Trichogramma* is not recommended in case of gram crop as it is not working due to acidic nature of the crop. In such cases the larval parasites like Braconid sp. may be augmented.

Innundative release involves mass multiplication and periodic release of natural enemies when pest populations approach damaging levels. Natural enemies are not expected to reproduce and increase in numbers. Control is achieved through the released individuals and additional releases are only made when pest populations approach damaging levels.

2. Inoculative releases: Inoculative releases are those, when the limited numbers of releases of bio-control agents are made timed with the presence of proper pest stage in the field. Thus we can say that Inoculative releases are those where large number of individuals are released only once during the season and natural enemies are expected to reproduce and increase its population for that growing season. Hence control is expected from the progeny and subsequent generations and not from the release itself.

Examples of natural enemies used in mass releases

Chrysoperla carnea: 8,000-10,000 larvae/acre at 10-15 days intervals

Trichogramma spp.:

- *Trichogramma chilonis* @ 1,50,000/ha at 10-15 days intervals

Epiricania melanoleuca: Field trials conducted by Dte. of PPQS have shown that in a problem area, field releases of 4000-5000 cocoons and 4-5 lakh eggs of *E.melanoleuca* per Ha where sugarcane Pyrilla incidence was noticed in the initial during July through proper surveillance, are likely to provide good control of Pyrilla pest

Recommended doses of bio-control agents by NBAII

Biocontrol Agent	Stage supplied	Systematic position	Target pest	Recommended dosage	No. of releases Recommended
PARASITOIDS					
Trichogramma Chilonis Ishii (I) #	Parasitised egg cards	Hymenoptera: Trichogrammatidae	Sugarcane borers *Chilo infuscatellus, Chilo sacchariphagus indicus, Chilo auricilius, Acigona steniellus;* Cotton (Non Bt) bollworms *Helicoverpa armigera, Pectinophora gossypiella* & *Earias* spp.; Maize stem borer *Chilo partellus,* Diamond back moth *Plutella xylostella;* Tomato fruit borer *Helicoverpa armigera*	50,000/ha on sugarcane and vegetables; 100,000/ha on maize and 1,50,000/ha on cotton	**Sugarcane**: 4 to 6 releases at 10 days intervals for early shoot borer; 8 to 10 releases for stalk, internode and Gurdaspur borers **Cotton (Non Bt) & Vegetables:** Six weekly releases **Maize: Three** releases at five days intervals
Trichogramma japonicum (I)	Parasitised egg cards	Hymenoptera: Trichogrammatidae	Top shoot borer of sugarcane *Scirpophaga excerptalis* and Paddy stem borer *Scirpophaga incertulas*	Sugarcane & Paddy: 50,000/ha	**Sugarcane:** 4 to 6 releases at 10 days intervals on observing pest or from 60th day **Paddy:** 6 releases on appearance of pest or from 30th day after transplantation
Trichogramma achaeae (I)*	Parasitised egg cards	Hymenoptera: Trichogrammatidae	Cotton (Non Bt) bollworms and Bhendi Borer	1,50,000/ha on cotton (Non Bt) 50,000/ha on vegetables	Six releases at weekly intervals
Trichogramma pretiosum (E)*	Parasitised egg cards	Hymenoptera: Trichogrammatidae	Tomato fruit borer *Helicoverpa armigera*	50,000/ha	Six releases at weekly intervals on appearance of pest or from 45th day from transplantation
Trichogramma embryophagum (E)*	Parasitised egg cards	Hymenoptera: Trichogrammatidae	Apple Codling moth *Cydia pomonella*	2000 adults per tree or 100,000/ha	Releases starting from the first moth catch, continue at weekly intervals till pest egg availability in the field

Trichogramma dendrolimi Matsumara (E)*	Parasitised egg cards	Hymenoptera: Trichogrammatidae	Targeted against tissue borers on maize and sugarcane	-	-
Trichogramma brassicae (E)*	Parasitised egg cards	Hymenoptera: Trichogrammatidae	Diamondback moth *Plutella xylostella* and Cabbage butterfly *Pieris brassicae* on cabbage and cauliflower	100,000/ha	Six releases at weekly intervals
Trichogrammatoidea bactrae (E)*	Parasitised egg cards	Hymenoptera: Trichogrammatidae	Diamond back moth *Plutella xylostella* on cabbage	2,50,000/ha	Five releases at weekly intervals
Telenomus remus Nixon (E)	Parasitised egg cards	Hymenoptera: Scelionidae	Tobacco caterpillar *Spodoptera litura*	1 lakh /ha	Three to four Releases
Goniozus nephantidis (Muesebeck) (I)	Cocoons	Hymenoptera: Bethylidae	Coconut black-headed caterpillar *Opisina arenosella*	10 adults per palm	Four releases
Chelonus blackburnii Cameron (E)*	Adults	Hymenoptera: Braconidae	Potato tuber moth *Phthorimaea operculella*	50000 adults /ha in the field 2 adults per kg of potatoes in godowns	Two releases at weekly intervals Three to four releases (or as per need) at fortnightly intervals
PREDATORS					
Cryptolaemus montrouzieri Mulsant (E)	Adults/ Grubs	Coleoptera: Coccinellidae	Mealy bugs *Maconellicoccus hirsutus, Planococcus citri, P. lilacinus*	10 beetles or 50 grubs /infested plant or tree or 5000 beetles/ha	One or more releases based on pest intensity
Scymnus coccivora (Ramakrishna Ayyar) (I)	Adults	Coleoptera: Coccinellidae	Mealy bugs on citrus, grapes and other fruit crops (*M. hirsutus, Planococcus* spp.	600 – 2500 adults/ha	One or more releases based on pest intensity

Chilocorus nigrita (Fabricius) (I)	Adults / Eggs	Coleoptera: Coccinellidae	Sugarcane scale insect *Melanaspis glomerata* Citrus scale *Aonidiella aurantii*	1500 beetles/ha; or 10 egg pads (with 40 eggs per pad) in 100 spots/ha (40,000 eggs/ha)10 adults/tree	One or more releases based on pest intensity
Cheilomenes sexmaculata Fabricius (I)*	Adults / Eggs	Coleoptera: Coccinellidae	*Aphis craccivora* on legumes and *Lipaphis erysimi* on oilseed crops	5000 larvae or 500 adults per ha	Two releases; first release to coincide with the appearance of aphids
Coccinella septempunctata Linnaeus (I)*	Adults / Eggs	Coleoptera: Coccinellidae	*Aphis craccivora* on legumes and *Lipaphis erysimi* on oilseed crops	5000 larvae or 500 adults per ha	Two releases; first release to coincide with the appearance of aphids
Brumoides suturalis (Fabricius) (I)*	Adults	Coleoptera: Coccinellidae	Aphids and white flies	-	-
Curinus coeruleus Mulsant (E)	Adults	Coleoptera: Coccinellidae	Subabul psyllid *Hetropsylla cubana*	20 Adults per tree	Two releases during July and October
Chrysoperla carnea (Stephens) (I)	Eggs / First instar larvae	Neuroptera: Chrysopidae	Sucking pests on cotton, tobacco, sunflower, groundnut& some fruit crops	10,000 first instar larvae/ha	Twice during the season with an interval of 15 days On fruit crops, 10 – 20 larvae per infested tree
Mallada spp. (I) *	Cocoons	Coleoptera: Coccinellidae	Sucking pests on cotton, tobacco, sunflower, groundnut& some fruit crops	10,000 first instar larvae/ha	Twice during the season with an interval of 15 days On fruit crops, 10 – 20 larvae per infested tree
Ischiodon scutellaris (Fabricius) (I) *	Cocoons	Diptera: Syrphidae	*Aphis craccivora* on legumes and *Lipaphis erysimi* on oilseed crops	5000 larvae/ha	-

Micromus timidus (Hagen) (I) *	Larvae	Neuroptera: Hemerobiidae	*A. craccivora* on legumes & oilseeds & Sugarcane Woolly Aphid	Research in progress	Research in progress
Cardiastethus exiguus Poppius (I)	Adults/ Nymphs	Hemiptera: Anthocoridae	*Opisina arenosella* Coconut black- headed caterpillar	50 nymphs/adults per tree	Three releases
Blaptostethus pallescens Poppius (I)	Adults/ Nymphs	Hemiptera: Anthocoridae	Spider mites on bhendi	5 to 10 nymphs per plant	Five releases

Sugarcane, Cotton and Vegetable strains of *T. chilonis* maintained; I: Indigenous; E: Exotic

Tips for Augmentation of Bio-control agents:

1. Always release ferrate adults (newly emerging adults) of parasitoids in the field. Release eggs/nymphs/grubs/adults of insect predators as the case may be.
2. Releases must be made in early morning or in evening hours.
3. Do not release long stored in fridge (over frozen) parasitized eggs.
4. Always see the percentage of parasitization on Trichocard before release.
5. Always release the Trichocard ensuring their safety with rain and wind conditions (adverse weather conditions).
6. Attempt larval parasites along with the egg parasites for augmentation to get the desired result.
7. Ensure quality of bio-control agents to be released.
8. Procure parasites from authentic source.
9. Develop field level technology for mass multiplication of bio-control agents.
10. Transfer/transport bio-control agents in ice boxes to avoid the emergence of adults on the way before releasing them in the field.
11. Crop specific strains of parasitoids should be released to get the desired control.
12. Indigenous bio-control agents are found more effective than exotic one.
13. Restrict/prevent movement of ants by banding with pesticide on tree trunks in orchards before releasing insect predators of mealy bugs.
14. Provide sufficient food for the insect predators in packages during transport before field release in order to prevent cannibalism.

Farmers can augment the number of natural enemies by bringing them from the field. for example, ladybird beetles or parasitized aphids/larvae/egg masses which contain young parasitoids.

Information on Bio-control agents against insect pests

Common name	Concept of active ingredient in the formulation	Target organism /host	Method of application	Recommended dose & mode of application	Reason for recommendation
Acerophagus papayae	Endoparasitoids of papaya mealybug	*On papaya mealybug Paracoccus marginatus*	Field release	250 per ha	To reduce mealybug infestation
Anagyrus loecki	Endoparasitoids of papaya mealybug	*On papaya mealybug Paracoccus marginatus*	Field release	250 per ha	To reduce mealybug infestation

Pseudleptomastyx mexicana	Endoparasitoids of papaya mealybug	*On papaya mealybug Paracoccus marginatus*	Field release	250 per ha	To reduce mealybug infestation
*Trichogramma chilonis*Ishii (I) # Hymenoptera: Trichogrammatidae	Parasitised egg cards	Sugarcane borers *Chilo infuscatellus, Chilo sacchariphagus indicus, Chilo auricilius, Acigona steniellus;* Cotton (Non Bt) bollworms *Helicoverpa armigera, Pectinophora gossypiella* & *Earias* spp.; Maize stem borer *Chilo partellus,* Diamond back moth *Plutella xylostella;* Tomato fruit borer *Helicoverpa armigera*	Field release	50,000/ha on sugarcane and vegetables; 100,000/ha on maize and 1,50,000/ha on cotton	**Sugarcane**: 4 to 6 releases at 10 days intervals for early shoot borer; 8 to 10 releases for stalk, internode and Gurdaspur borers **Cotton (Non Bt) & Vegetables:** Six weekly releases **Maize: Three** releases at five days intervals
Trichogramma japonicum (I) Hymenoptera: Trichogrammatidae	Parasitised egg cards	Top shoot borer of sugarcane *Scirpophaga excerptalis* and Paddy stem borer *Scirpophaga incertulas*	Field release	Sugarcane & Paddy: 50,000/ha	**Sugarcane:** 4 to 6 releases at 10 days intervals on observing pest or from 60th day **Paddy:** 6 releases on appearance of pest or from 30th day after transplantation
T. achaeae (I)* Hymenoptera: Trichogrammatidae	Parasitised egg cards	Cotton (Non Bt) bollworms and Bhendi Borer	Field release	1,50,000/ha on cotton (Non Bt) 50,000/ha on vegetables	Six releases at weekly intervals
Trichogramma pretiosum (E)* Hymenoptera: Trichogrammatidae	Parasitised egg cards	Tomato fruit borer *Helicoverpa armigera*	Field release	50,000 /ha	Six releases at weekly intervals on appearance of pest or from 45th day from transplatation
Trichogramma embryophagum (E)* Hymenoptera: Trichogrammatidae	Parasitised egg cards	Apple Codling moth *Cydia pomonella*	Field release	2000 adults per tree or 100,000/ha	Releases starting from the first moth catch, continue at weekly intervals till pest egg availability in the field
Trichogramma	Parasitised egg	Diamondback	Field release	100,000	Six releases

brassicae (E)* Hymenoptera: Trichogrammatidae	cards	moth *Plutella xylostella* and Cabbage butterfly *Pieris brassicae* on cabbage and cauliflower		/ha	at weekly intervals
Trichogramma atoidea bactrae (E)* Hymenoptera: Trichogrammatidae	Parasitised egg cards	Diamond back moth *Plutella xylostella* on cabbage	Field release	2,50,000 /ha	Five releases at weekly intervals
Telenomus remus Nixon (E) Hymenoptera: Scelionidae	Parasitised egg cards	Tobacco caterpillar *Spodoptera litura*	Field release	1 lakh /ha	Three to four releases
Goniozus nephantidis (Muesebeck) (I) Hymenoptera: Bethylid	Cocoons	Coconut black-headed caterpillar *Opisina arenosella*	Field release on tree trunks	10 adults per palm	Four releases
Chelonus blackburnii Cameron (E)* Hymenoptera: Braconidae	Adults	Potato tuber moth *Phthorimaea operculella*	Field release	50000 adults /ha in the field 2 adults per kg of potatoes in godowns	Two releases at weekly intervals Three to four releases (or as per need) at fortnightly intervals
Cryptolaemus montrouzieri Mulsant (E) Coleoptera: Coccinellidae	Adults / Grubs	Mealy bugs *Maconellicoccus hirsutus, Planococcus citri, P. lilacinus*	Field release	10 beetles or 50 grubs /infested plant or tree or 5000 beetles/ha	One or more releases based on pest intensity
Scymnus coccivora (Ramakrishna Ayyar) (I) *Coleoptera: Coccinellidae*	Adults	Mealy bugs on citrus, grapes and other fruit crops (*M. hirsutus, Planococcus* spp.	Field release	600 – 2500 adults/ha	One or more releases based on pest intensity
Chilocorus nigrita (Fabricius) (I) Coleoptera: Coccinellidae	Adults / Eggs	Sugarcane scale insect *Melanaspis glomerata* Citrus scale *Aonidiella aurantii*	Field release	1500 beetles/ha; or 10 egg pads (with 40 eggs per pad) in 100 spots/ha (40,000 eggs/ha) 10 adults/tree	One or more releases based on pest intensity
Cheilomenes sexmaculata Fabricius (I)* Coleoptera:	Adults / Eggs	*Aphis craccivora* on legumes and *Lipaphis*	Field release	5000 larvae or 500 adults per ha	Two releases; first release to coincide with the appearance

Coccinellidae		*erysimi* on oilseed crops			of aphids
Coccinella septempunctata Linnaeus (I)* Coleoptera: Coccinellidae	Adults / Eggs	*Aphis craccivora* on legumes and *Lipaphis erysimi* on oilseed crops	Field release	5000 larvae or 500 adults per ha	Two releases; first release to coincide with the appearance of aphids
Curinus coeruleus Mulsant (E) Coleoptera: Coccinellidae	Adults	Subabul psyllid *Hetropsylla cubana*	Field release	20 Adults per tree	Two releases during July and October
Chrysoperla carnea (Stephens) (I) Coleoptera: Coccinellidae	Eggs / First instar larvae	Sucking pests on cotton, tobacco, sunflower, groundnut& some fruit crops	Field release	10,000 first instar larvae/ha	Twice during the season with an interval of 15 days On fruit crops, 10 – 20 larvae per infested tree
Mallada spp. (I) * Neuroptera: Chrysopidae	Cocoons	Sucking pests on cotton, tobacco, sunflower, groundnut& some fruit crops	Field release	10,000 first instar larvae/ha	Twice during the season with an interval of 15 days On fruit crops, 10 – 20 larvae per infested tree
Ischiodon scutellaris (Fabricius) (I) * Diptera: Syrphidae	Cocoons	*Aphis craccivora* on legumes and *Lipaphis erysimi* on oilseed crops	Field release	5000 larvae/ha	One or more releases based on pest intensity
Cardiastethus exiguus Poppius (I) Hemiptera: Anthocoridae	Adults/Nymphs	*Opisina arenosella* Coconut black-headed caterpillar	Field release	50 nymphs/adults per tree	Three releases
Blaptostethus pallescens Poppius (I) Hemiptera: Anthocoridae	Adults/Nymphs	Spider mites on bhendi	Field release	5 to 10 nymphs per plant	Five releases
Heterorhabditis indica (Entomo pathogenic nematodes)	Infective juveniles in wettable powder	White grubs, Root weevils & soil pests	Soil Application	20k g/ha	For combating Soil insect pests and reducing chemical insecticide usage
Bacillus thuringiensis	*Bt* crystals and Bt spores 5%	Lepidopteran, coleopteran and dipteran pests of crops	Foliar spray	1kg/ha	To reduce the use of chemical pesticides
Spodoptera litura	Poly hedral bodies of the	*Spodoptera litura*	Foliar spray	250 Larval Equivalent	To reduce the use of

Nuclear Polyhedrosis virus(Sl NPV)	NPV Virus 1 X 10^9PIB/ml			(LE) /ha	chemical pesticides
Helicoverpa armigera Nuclear Polyhdrosis virus(Ha NPV)	Poly hedral bodies of the NPV Virus 1 X 10^9PIB/ml	*Helicoverpa armigera*	Foliar spray	250 Larval Equivalent (LE) /ha	To reduce the use of chemical pesticides
Beauveria bassiana	Spore cum mycelia formulation 1X10^8 CFU/g/ml	Several insect pests of crops		2.5-5.0kg/ hafor foliar spray 2.5-5.0 kg+250-500kg FYM /ha for soil application	For combating insect pests and reducing chemical insecticide usage
Metarhizium anisopliae	-do-	-do-	-do-	-do-	-do-
Verticillium lecanii	-do-	Sucking pests of various crops	Foliar spray	2.5-5.0kg/ hafor foliar spray	-do-
Paecilomyces fumosoroseus	-do-	For mite control	-do-	2.5-5.0kg/ hafor foliar spray	-do-

Chapter-III

Pests Surveillance & Monitoring

Standard Operating Procedure (SOP) For Pests Surveillance & Monitoring

Process to find the target pests in the surveyed area is expressed as surveillance and the methods to find the target pests is monitoring. Hence by monitoring of pests one can perform surveillance.

Surveillance is the constant, systematic watch of biotic and abiotic factors of the crop ecosystem in order to predict the pest outbreak. In pest surveillance programmes one studies the population dynamics and the key natural mortality factors operating under field conditions which help in devising the appropriate management strategies.

(Close watch= निगरानी). It is observing something for a long period of time

Pest surveillance implies close and regular vigilance over the development of

- insect-pest population
- disease
- weeds, and
- bio-control agents

Whereas **Survey** is conducted to study the abundance of a pest species. The **s**urvey conducted over a defined period of time and detailed inspection to determine the characteristics of a pest population or which pest species occur in an area is called as pest survey.

IPM Umbrella

AGENCIES TO BE INVOLVED FOR SURVEILLANCE:

- State Department of Agriculture / Horticulture
- State Agricultural Universities.
- Indian Council of Agricultural Research Institute.
- Crop based Directorates of Department of Agriculture and Co-operation of Government of India.

AIMS & OBJECTIVES OF SURVEILLANCE

In general, Survey/Surveillance is of two types:

1. General Pest Surveillance (Crop Specific)
2. Specific Pest Surveillance (Pest Specific)

Crop pests surveys are conducted to monitor the pest population on different crops in the area and to generate field data of -

- Ecology
- Epidemiology of major pest and diseases
- Reaction of crop variety
- Estimation of crop losses
- Status of pest & diseases
- Role of Bio-control agents

WHY TO CONDUCT PEST SURVEILLANCE:

Pest Surveillance is under taken for the following purposes:-

1. To monitor and forewarn the crop pests, diseases, weeds, and Bio-control agents population buildup in the agricultural crops.
2. To monitor the locust population in the Scheduled Desert Area (SDA) of Rajasthan and Gujarat States of India.
3. To know the occurrence of pests and provide basis for pest identification, listing of pest, pest status, pest categorization, to conduct risk analysis and to earmark the pest prone and pest free areas as a pre-requisite for phyto- sanitary measures and agreement for global trade.

ADVANTAGES OF SURVEILLANCE

- ⇨ to know existing and new species in an area
- ⇨ to assess pest population and damage at different growth stage of crop
- ⇨ to assess natural enemies population and their build up at different growth stage of crop
- ⇨ to study the influence of weather parameters on pests & their natural enemies
- ⇨ to study pest status change on a particular crop
- ⇨ to assess abundance of natural enemies and their influence on pests
- ⇨ to evaluate effect of new cropping pattern and varieties on pest
- ⇨ to determine pest trends affecting agricultural management practice
- ⇨ to alert growers and other agriculture professionals to the presence of plant pests and outbreaks.

INSECT FORECASTING MAY SERVE AS

- To predict the forthcoming infestation level of pest

- To find out the critical stage at which management practices should apply

OUTCOME OF THE SURVEILLANCE ACTION:

The surveillance programme is beneficial for:-

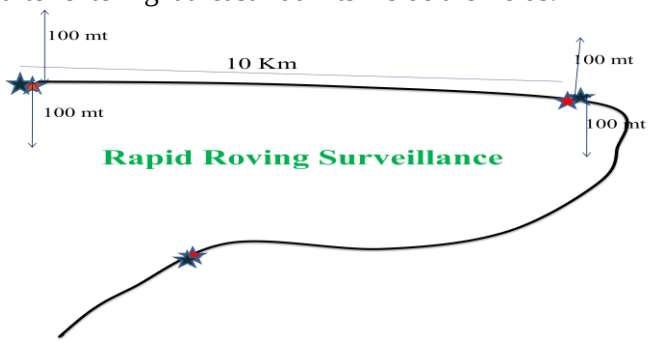
1. Early detection of pest occurrence, outbreaks, upsurges
2. For making suitable pest management strategy before the pest causes the economic loss.
3. For adopting timely pest management measures.
4. For earmarking the endemic, hot spots and pest free areas.
5. For making forewarning and issuing of timely advisory to farmers and State Governments.
6. For managing the pest emergencies.
7. For knowing the emerging pest problems.
8. For checking further spread of the pest in the other areas.
9. 10.For adopting pro-active steps for expected pest problems.

TYPES OF SURVEY:

- **Qualitative survey**: Useful for detection of pest
- **Quantitative survey**: Useful for enumeration of pest i.e. numerically abundance of pest population in time and space
- **Fixed Plot Survey**: In this programme cultivated area is divided into four sectors with the help of officer-in- charge of the area. All sectors should be of equal size. Each of these sectors must be accessible by road and properly shown in a map, showing number of villages in each sector. Each sector should have 3 observational fields of about an acre area. Each field should be at least a mile apart from each other. Thus there will be in all 12 observational fields with each technical observer. Every field cultivator must be personally contacted by the technical observer to seek his co-operation that is going to happen while making observations in those fields. Each observer is required to pay two visits to each of his observation fields per week and survey and sample the pest and natural enemies' population in accordance with sampling methods. An acre plot may be divided into 5- micro plots of meter square area one each in four corners (6-100 meters away from bund) and fifth in the centre. Periodical assessment is done in these chosen micro plots. Agro-ecological parameters have also to be noted. Each technical observer will fill the field card (See model ann-I&II) each time he makes trip to his fields. A note book should be along with him to note down any details which cannot be accommodated in the field cards and should be designated as "Comments". He should report to his in-charge on weekly basis. Report thus prepared should be submitted to his in- charge who in turn will sent it to State Plant Protection Authority, Directorate Head quarters and state Research Units.

These plots are to be kept free from chemical sprays till Economic Threshold Level (ETL) is reached.

Roving Survey: Roving Survey is performed by assessing pest population/ damage wherein pest information is gathered from randomly selected spots over large area in a short period. The survey routes to be finalized before the commencement of the seasons (Kharif/ Rabi) in consultations with state department of agricultural officials. The survey routes should cover major crops grown in the state. The survey team should be finalized before onset of surveillance programmes. The time interval between surveys should be at least a minimum of ten days. The survey should spread over in the entire crop season. The survey report finalized and sent to Head quarters and to concerned district head of state Departments through fastest mode. Wherever forewarning is required to be issued, it should be done on the same day during survey period. A minimum of 200-250 Kms is covered in a day. Observations are done at least at every ten kilometer distance and on both sides of the road. The observation is performed after entering at least 100 mts inside the fields.



Single Point Survey (Eye ball method of survey):

A qualified plant Pathologist traverses through the cropped area, halts at periodic intervals to inspect crop health and record all observations. This method helps to understand the immediate course of action needed to maintain crop health.

Multiple point survey:

This is conducted at different crop growth stages and enables to identify major production constraints and predict yields. Such methodically collected data for a few crop seasons through

regular surveys provide necessary information in developing disease management strategies.

ELECTRONIC-PEST SURVEILLANCE THROUGH HAND HELD DEVICE:

The foundation of electronic pest surveillance primarily is based upon to collect, store, access, capture and transfer pest information to all concerned. This helps the delivery of data through fastest mode. The e- surveillance targets the critical requirements of a crop cycle, *i.e.* pest management. The collection of crop data manually is laborious and at the same time takes a lot of time to transfer from field to the decision making authorities. This methodology provides the required solution. It is estimated that the timely intervention in the crops may reduce the crop losses as much as 25-30 percent.

- The hand Held Device (Data Logger) is an important field data capture system (qualitative), quantitative with Geo-referencing.
- The device has inbuilt Global Positioning System (GPS) so that geo-referenced field data can be collected.
- At the end of the pest surveillance the device would generate a data file which can be easily transferred through Internet to centralized database for Analysis and transferring data into usable report.
- The project was taken up in couple of states and is being pursued by the Directorate to be implemented through the CIPMCs.

Data Transmitting & Storage System

- dacnet/pdmis System : It is a system on pest observations, at district level; the system runs at state level and a subset of the data is also visible at national level (crop, crop stage, pest, extent of disease/infestation); the source, and principal user, is State departments of agriculture, and it is also used to manage pesticide availability
- http://dacnet/iipm System: It is a system to support entry of the results of roving survey reports, and includes the potential to report a more complete view with Agro Ecosystem Analysis (additionally numbers of pests, predators, field conditions, weather, etc) and is designed to administer CIPMC roving survey data

PEST SURVEILLANCE AND ADVISORY SYSTEM IN INDIA

National Pest Surveillance and Advisory Unit. It is composed of

1. Joint Secretary (Plant Protection), DAC, Chairman
2. ADG (PP), ICAR , Member
3. Plant Protection Advisor, Dte of PPQ & S, Member Convener
4. Director, NCIPM (ICAR), Member
5. Representatives of crop specific ICAR Institutions – Invited by the Committee
6. Representatives of State Agriculture Universities – Nominated by the Committee
7. Selected Commissioners/ Director of Agriculture -Depending on the season and crop
8. Representatives of NIC
9. Representatives of farmers - Nominated by the Committee

Functions:

- Coordinating pest surveillance and providing guidance to the CIPMCs and States
- Analysis of pest surveillance data and advice on emerging pest threats
- Enabling the research Institutes for taking up special and time bound activities in special areas
- Launching campaign for creating farmer awareness on specific situations where community action is required
- Advising the neighboring States on possible pest migration.

State Pest Surveillance and Advisory Unit

- Commissioners/ Director, State Department of Agriculture - Chairman
- Director of Research, State Agriculture University
- Plant protection experts from State Agriculture University
- Representatives of ICAR Research Institute in the State
- Selected District Joint Directors depending on crop season and area
- Representatives of CIPMC of the State
- Coordinator of KVK in the State
- Farmers representatives
- Selected NGO active in plant protection areas
- Joint Director/ Deputy Director (PP) - Member Convener

Functions:

- Direct State-wide multi-district surveillance activities and manage the data
- Arranging training of personnel and extend support for district level surveillance
- Analyze reports on the pest and disease situation district wise

- Log all issued advisories and ensure that advisories and other activities are consistent with guidance given
- Confirm issuing of any State-wise advisories prepared by SAU, if needed
- Arrange special surveys or surveillance depending on the need

DISTRICT PEST SURVEILLANCE AND ADVISORY UNIT

- Joint Director (Agriculture/ Horticulture)- Chairman
- Representatives of KVK
- Representatives of local research institute of SAU and/or ICAR
- Block Agriculture Officers depending on the season and crop
- Representatives of farmers groups
- Assistant Director/ Deputy Director (PP) - Member Convener

Functions:

- Direct and coordinate local arrangements / activities on pest and disease surveillance and review results and draft appropriate advisories
- Arrange to send the data to State and National units
- Communicating the advisories to farmers through mass media and print media
- Taking up special campaigns for surveillance and pest control practices
- Involving the farmers groups, commodity groups, NGOs in surveillance and special campaigns.

Survey/Surveillance for Assessment of Insect Population

1. Stage of the pest & natural enemies to be counted.
   (Egg, Larva, Pupa, Adults)
2. Actual process of counting Sampling - Distribution of pest
   - Percent infection/infestation
   - Count in number
   - Availability of natural enemies
   - Weather parameter
   - Variety is Susceptible or resistant

Factors affecting insect pest population

1. Climate
   - Temperature
   - Relative humidity
   - Rainfall
   - Day length
2. Migration: Locust swarm etc.
3. Crop variety- HYV= are more susceptible for particular pests, consider them
4. Agronomic practices-
   spacing, planting date, nitrogen application

SAMPLING

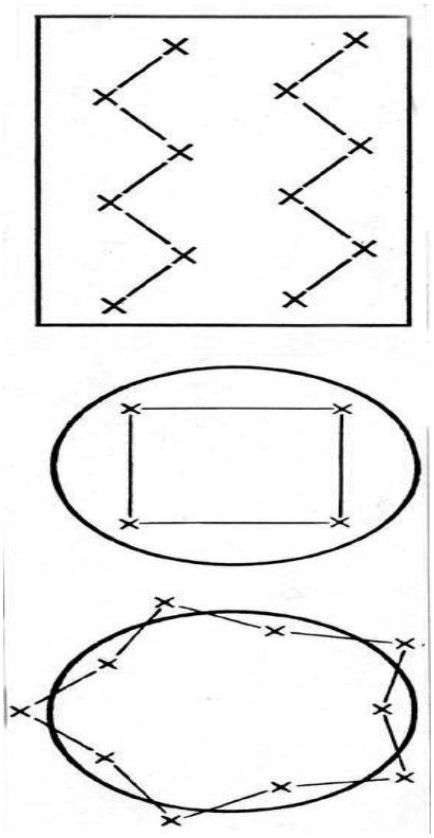
A. Sample: A set of unit or portion of aggregated material which represents the whole population.

Sampling helps –

- Identifying & monitoring pests & natural enemies
- Understanding biological & environmental factors that affect pests & natural enemies
- Using treatment threshold for control decisions
- Knowing efficacy of control tactics & impact on non-target pests & natural enemies

Sampling patterns:

- **Zigzag pattern**- Sampling a fallow field or one with no obvious symptoms in the current crop to see the incidence- viral, wilt
- **Square pattern**- Sampling within the drip line of trees and shrubs
- **Star pattern**- Sampling from a damaged area.
- **At random pattern**- Through the square (1m x 1m) in field (4-5 points)



ITEMS REQUIRED FOR SURVEY & SURVEILLANCE IN THE KIT:

1. Vehicle (4 wheel drive) with driver
2. Survey route map
3. Survey Proforma
4. Pen or pencil, Eraser, Sharpener
5. Writing pad
6. Collection vials with lid
7. Cotton
8. Rubber bands
9. Brush
10. Needle
11. Thread
12. Polythene bags, Butter bapers
13. Sweeping / butterfly net
14. Watch glass
15. Hand lenses of different capacity
16. Chloroform
17. Killing bottle
18. Pruning knife
19. Spade
20. Khurpi/ Spade
21. Meter square/Quadrant
22. Kit bag
23. Hand Gloves
24. Gum boots/sleeper
25. Forceps
26. Scissors
27. Cloth
28. Muslin cloth
29. Field cap
30. Rain coat/Umbrella
31. Stapler with pins
32. Blotting paper
33. Herbarium press
34. Entomological pins
35. Paper soap/liquid soap
36. Torch with cell
37. First aid box with medicines
38. Blade
39. Drawing sheets
40. Sketch pens
41. Field camera
42. Mobile phone
43. Water bottle
44. Stick
45. Half pant
46. Field Apron/T-shirt
47. Measuring tape
48. Tags/Labels
49. Drain Spades
50. Scoop

SAMPLING METHODS:

1. NET SWEEPING
2. SUDDEN TRAPPING
3. LIGHT TRAPS
4. SUCTION TRAP
5. ADHESIVE OR STICKY TRAPS
6. BAIT TRAPS
7. PHEROMONE TRAPS
8. WATER PAN METHOD
9. CROP SAMPLES
10. PIT FALL TRAP
11. PLANT SHAKE METHOD

SQUARE METER:

In the sampling techniques, the square meter has been very often referred to for sampling of various insect- pests- diseases and weeds. It is a square, formed of four one meter long and about a quarter cm thick iron wire firmly fastened at the corners to be thrown in the observation field for random sampling. It should be sufficiently firm and rigid in maintaining the square shape to stand field use.

NET SWEEPING

The points to be considered

- time of sampling
- density and height of the crop
- number of sweeps required
- the type of insect pest involved in the study.

A sweep net is an important item in the sampling and the collection kit. It must be rigidly constructed and handled with care. A standard sweep net is 15 inches diameter loop, 24 inches long bag made of muslin coarse cloth, and a sturdy 40 inches long handle.

A sidewise sweep will collect more insects than an upward or downward sweep and at the same time there will be less injury to the insects. Swing the net the way in which the pendulum of a clock swings. One sweep is equal to 1 pass of the net, and the return pass is counted as the second sweep. The number of sweeps required to sample an insect is relative to the population level but the data should be reported as number of insects per sweep. Usually ten sweeps may be sufficient to assess the general population

LIGHT TRAPS

This method is useful in the quantitative estimation of seasonal abundance of several species of many moths and other insects which are attracted to light.

The brood emergence of the rice stem borer *Scirpophaga incurtulas* is fixed by light trap catches.

SUCTION TRAP

In this method the flying insects are trapped by sucking air in to some form of trap with a suction apparatus operated either by hand or by means of a motor. With timing mechanism it is possible to have hourly catches.

ADHESIVE OR STICKY TRAPS

A suitable persistent adhesive material like grease, tar etc. which will not dry out is spread on strips of paper and supported on a cylinder. Such sticky traps are set in fields and flying insects are trapped in them. The factors like wind velocity, temperature, colour of the trap etc. have a bearing on the number of insects caught in such traps. It is also necessary to collect and clean the traps often, otherwise the efficiency of the trap may go down.

BAIT TRAPS

- Many materials varying from raw plant materials and crushed insects to refined chemicals attractants which stimulate sexual odors or food odors are known to attract insects. These materials are used as baits in special types of traps made for the purpose depending on the insect species to be trapped.
- Insects (termite)
- Snails (Metaldehyde)
- Rats (Zinc phosphide, Bromadiolone)

WATER PAN METHOD

In this method a wide mouthed plastic container is used with water. Few drops of detergent or teepol is added to reduce the surface tension and for easy settling of insects at the bottom of the container. The plastic container with water is taken to the bottom of rice plant and the hills are tapped three times enabling the insects etc to fall inside the pan. It is repeated in ten different hills and the insects thus collected are be separated out as pests and defenders. This method is useful for the insects which feed at the basal portion of rice plant.

PLANT SHAKE METHOD

- A white paper is kept underneath the plant and shaking of the branches is done.
- The insects falling from the plant are identified and sampled.

What to record on data sheet?

- Season
- Crop
- Variety/Hybrid name
- DOS/DOT
- Stage
- Period
- Date
- Weather condition
- Name of the farmer
- Soil condition
- Soil Type
- Previous history (if any)
- Previous crop
- Pests and bio-agents observed (its stage, count per unit)
- Diseases
- Weeds
- Rodent infestation

B. DISEASE ASSESSMENT

- Determination / measurement of plant disease incidence or intensity

Objectives

- For taking up timely management practices
- To assess disease resistance
- To assess crop losses

Incidence

- No. of plant units infected and expressed as percentage to total units examined, e.g. wilt

Severity

- Area of plant tissue affected and expressed as percentage to total units examined

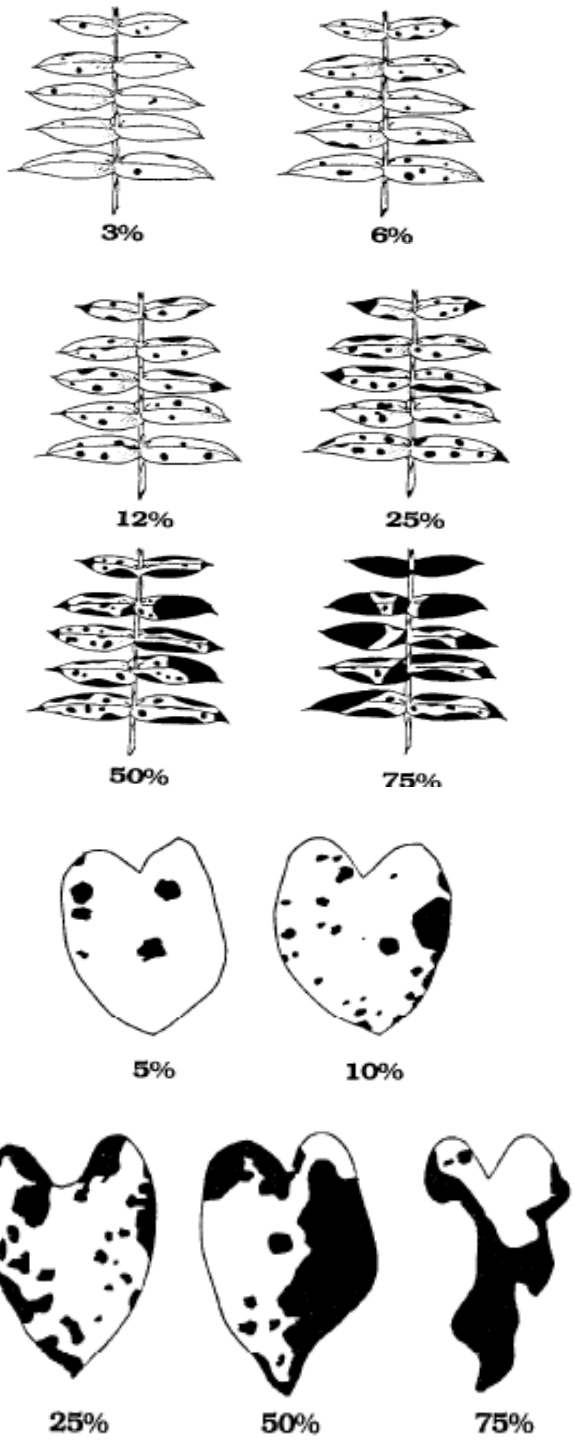
Disease incidence & Intensity

$$\text{Disease incidence \%} = \frac{\text{No. of plant sample infected}}{\text{Total no. of plant sample collected}} \times 100$$

$$\text{Disease severity \%} = \frac{\text{Area of plant tissue affected}}{\text{Total area}} \times 100$$

$$\text{Disease index \%} = \frac{\text{Sum of individual ratting} \times 100}{\text{Total no. of samples collected x Max. rating}}$$

DISEASE ASSESSMENT KEYS:



C. SAMPLING FOR NEMATODES

Sampling and extracting of nematodes serves two purposes

- Diagnosis a current problem
- Predict a future problem

Sampling can be carried out at random or systematically.

Depends on kind of plant:

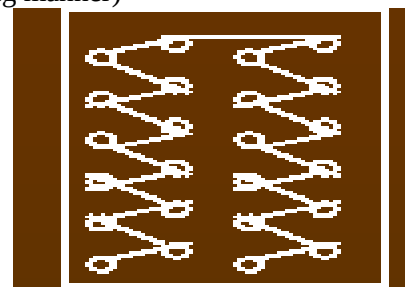
1- Soil sampling

2- Plant sampling

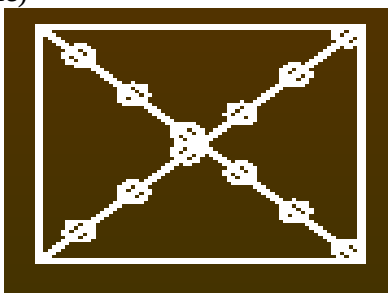
Soil Sampling

Prior to sampling a field plot may be divided into strips or blocks

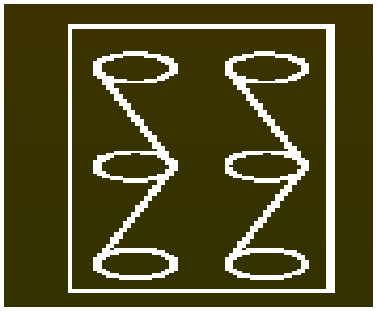
- Systematic at equally-spaced point according (Zigzag manner)



- At equally-spaced points along a line running diagonally across a field (crossing the field at middle)

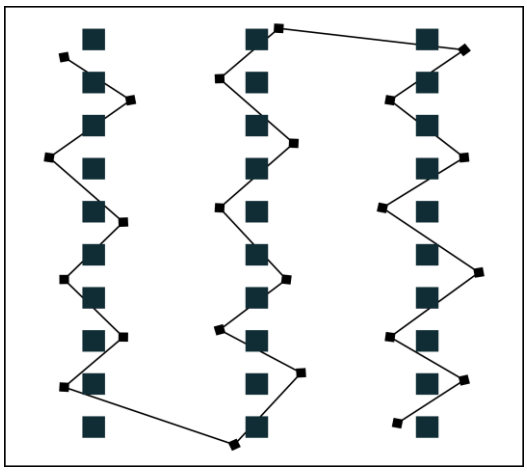


- Sample tree crops on alternate sides of the trunks and include feeder roots



Sampling pattern:

- If plants are not present, sample in the row
- If plants are present, sample just outside the row
- Take 4-5 cores to make a composite soil samples



- Collect sample from:
  - *roots
  - *leaves
  - *stems
  - * buds & flowers
  - * fruits
  - *seeds
- Timing:
  - *at seedling
  - * flowering
  - * fruiting
  - *maturation stage

Material for sampling

- Never uproot plants or take soil samples by hand
- Soil sampling tube (15-20 cm)
- Soil auger (more than20 cm)
- Spade or garden trowel
- Label each sample directly on the bag with a permanent marker, including field location, date, tillage history and rainfall to-date.
- Don't leave bagged samples out in the sun. If necessary, store in a cool, dry place.
- Pack samples in a cooler for transport or an insulated box for shipping.
- Speed is essential – ship as soon as possible.

D. RODENTS SURVEY

- Sighting the actual damage/loss
- Live burrow counts
- Census baiting
- Trapping

LIVE BURROW INDEX

- Plug all burrows in the evening hours.
- Observe and count the next morning reopened burrows per unit area (called as live/active burrows)
- Burrow index:
  - 0-25/ha : low
  - 25-50/ha: Moderate
  - 50 & above: High

E. ESTIMATION OF WEEDS:

Visual estimation is followed by taking quick look at the entire field to have an idea of weeds in different parts of the field. Also vigour and growth of main crop and the weeds are taken. Emphasis must be given on an unbiased estimate. This survey can be combined with the other crop pest- diseases survey. Samples must be taken away from the main roads. At least 3-10 samples should be taken for an hectare area. The samples should be taken with the help of 1m x 1m quadrant. Weeds must be identified, counted, recorded in proforma. Unidentified weeds should be collected preserved for further action. Broad leaved, grasses, sedges etc are accordingly separated.

The field sampling technique for weeds:

To understand the impact of weeds on a habitat, weed infestations can be sampled and possibly mapped. To manage the weeds, sampling and mapping give valuable information on what IPM tactics will be used and when to use.

The goal of sampling is to get an accurate estimation of the potential weed population in a

given area. The sampling technique must adequately represent the whole area. For example, in a field, do not just sample on the edge of the field because this would give you an inaccurate estimate of what is going on in the whole field. Mapping of where exactly the weeds are may allow you to spot treat rather than do something on the whole field.

Your goal in sampling must be understanding of the species composition of an area or gaining information in order to make management decisions. The type of sampling used will depend on what you want to know and what environment you are sampling in. For example, for farm situations, there are established "economic thresholds" of tolerance for weeds. Above that level, the weeds will cost the farmer money if he does not do something to knock them back.

Learning Objectives:

- Try and compare sampling techniques for weeds
- Learn plant identification
- Learn factors involved in management decisions based on sampling information
- Discover the concepts of species diversity and distribution within habitats

Materials Needed:

- paper and/or data sheets
- long tape measures to set up transects
- meter square
- weed identification books or charts
- hand lens
- zip lock bags if specimens are to be brought back for identification

Timeline:

Depends upon how in-depth study has to done. Whether several class periods, or partial or all day field activity.

Procedures:

1- Select several locations where sampling of weeds has to be done.
2- Lay out a transect across the environment and predetermine at what distance intervals one will stop and sample.
3- Transect method - at each predetermined point on the transect, stop and write down the plant species touching or closest to each side of the tape at the stopping point. Do this until all points are sampled.
4- Quadrat square method - go back and stop again at the same points. This time, set the corner of the quadrat square down at the stopping point parallel to the tape. Inside the square, see how many different plant species you can find. List them. Make an estimate of what percent of the ground within the quadrat is covered by each of the species. Determine if the plant species are evenly distributed or clumped.

Data collection:

Transect method - list species found at each interval as described above. You can also take measurements like plant height, stage of growth or other factors that are relevant in that habitat.

Quadrat method - list all plant species found inside quadrate with % cover

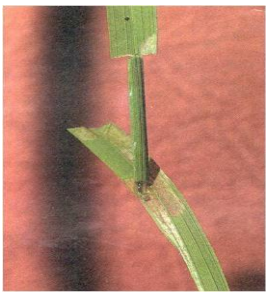
IDENTIFICATION OF DISEASES, PESTS, WEEDS, NATURAL ENEMIES IN DIFFERENT CROPS

Insect-Pests of Paddy


Thrips (Nymph & Adult)



Green Leaf Hopper



Rice case worm symptom & its larvae



Paddy stem borer attack & its egg mass




Swarming Caterpillar (L,P,A)



Rice Skipper symptoms, its larvae & Adult Gall



Midge


short horned grass hopper




Rice leaf folder symptoms its larvae & adult)


Gundhi bug



Whorl maggot (A,L)




Rice Hispa symptoms, its larvae & adult

Diseases of Paddy


Sheath blight


Bacterial blight


Rice Blast




BPH WBPH Mealy bug


sheath rot


Tungro

Major weeds of paddy crop


Echinochloa colona


Echinochloa glabrescens

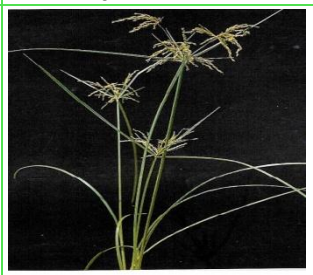

Echinochloa crusgalli


Ageratum conyzoides


Amaranthus spinosus


Fimbristylis miliaceae


Cyperus difformis


Cyperus iria

Pests & Diseases of cotton


Jassid


Aphid


White fly


Thrips


Mealy Bug


American bollworm


Pink bollworm


Spotted bollworm

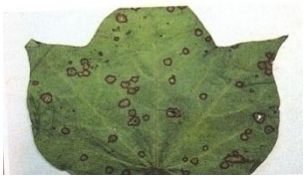

Spodoptera. litura


Semi looper


Black arm


wilt


Damping off


Alternaria leaf spot


Anthracnose


Cercospora leaf spot


Grey Mildew


Leaf curl


Root knot


Sting nematode


Common bunt


Fusarium head blight


Loose smut


Bacterial streak

Wheat diseases and pests


Yellow rust


Karnal bunt


Brown rust


Powdery mildew


wheat aphid

Annexure-I

RICE SURVEY FIELD CARD
(MODEL)

Survey routes:
(i)
(ii)
(iii)
(iv)
State:_____
Reporters:_____Date:_____

I - Location Details						
Field & Mile stone no.						Remarks
Village						
Block						
District						
II – General Information *						

Variety						
DOS/DOT						
Crop stage						
Crop Appearance						
Water						
Weather						
Weeds						
Deficiency						
III - Pests**						
Leaf Folder						
Stem Borer						
Rice Hispa						
Green Leaf Hopper						
Gall Midge						
Case worm						
Grasshopper						
BPH						
WBPH						
Whorl maggot						
Others 1						
2						
3						
Rats Live burrows (number)						
IV- Defenders: ***						
Spiders						
Coccinellids						
Damsel/Dragon fly						
Carabid						
Staphylinid						
Mirid bug						
Tetrastichus Egg parasites						
Telenomus						
Bracon						
Ichneumonids						
Pathogens						
Others 1						
2						
3						

V- Diseases**						
Sheath blight						
Sheath rot						
Rice blast						
False smut						
Brown spot						
Bacterial blight						
Tungro						
Others 1						
2						
3						

* Use following codes for recording general information

Variety: Local (1); Hybrid (2)

Planting Method: Broadcasting (1); Transplanting (2)

Crop Stage: Seedling (1); Tillering (2); Booting (3); Heading (4); Flowering (5); Milky (6); Dough (7); Matured (8)

Crop appearance: Healthy (1); Yellowing (2); Browning (3); Dead (4)

Water: Flooded (1); Muddy (2); Dry (3)

Weather: Sunny (1): Cloudy (2); Drizzle (3); Rainy (4)

Weeds: Low (1); Moderate (2); Heavy (3)

** Observe 20 plants diagonally across the field and record the pests/diseases and BCA (Bio-control agents) by using following scales:

0 Nil; Low (L)- < 5 % damage; Moderate (M)- 5-10 % Damage; severe (S) > 10% Damage

*** Use following scale for recording defenders: 0- Nil; 1- Low ; 2- Moderate ; 3- Abundant

Annexure-II

SUGARCANE SURVEY FIELD CARD (MODEL)

Survey routes:
(i) (ii) (iii) (iv)
State:_____
Reporters:_____ Date:_____

I - Location Details						
Field & Mile stone no.						Remarks
Village						
Block						
District						
II – General Information *						
Variety						
DOS/DOT						
Crop stage						
Crop Appearance						
Water						
Weather						
Weeds						
Deficiency						
III - Pests**						
Pyrilla						
Shoot Borer(Early/Top etc)						
Stem borer						
White fly						
Aphids						
Black Bug						
Mites						
Scale						
Termites / White grub						
Mealy Bug						
Black bug						

Others 1						
2						
3						

Tetrastichus Egg parasites						
Telenomus						
Bracon						
Ichneumonids						
Pathogens						
Others 1						
2						
3						
4						
V- Diseases**						
Red Rot						
Leaf Spot						
Grassy shoot						
Leaf blight						
Mosaic						
Scald						
Whip smut						
Others 1						
2						
3						
4						
Rats Live burrows (no.)						

* Use following codes for recording general information
Variety: Local (1); Hybrid (2);
Crop Stage: Seedling (1); Tillering (2); Cane Formation (3); Maturity (4)

Crop apearance: Healthy (1); Yellowing (2);

Water: Flooded (1); Muddy (2); Dry (3)

Weather: Sunny (1): Cloudy (2); Drizzle (3); Rainy (4)

Weeds: Low (1); Moderate (2); Heavy (3)

** Observe randomly the field and record the pests/diseases & BCA(Bio-control agents) by using scales:

IV- Defenders: ***						
Spiders						
Coccinellids						
Damsel/Dragonfly						
Carabid						
Staphylinid						
Mirid bug						

0 Nil; Low (L)- < 5 % damage; Moderate (M)- 5-10 % Damage; severe (S) > 10% Damage
*** Use following scale for recording defenders: 0- Nil; 1- Low ; 2- Moderate ; 3- Abundant

Chapter-IV

Weed Ecology & Management

WEED ECOLOGY AND MANAGEMENT

1. Introduction

Weed is a plant growing where it is not desired. Weed is an unwanted plant in a specific crop ecosystem. Weeds are the serious pest and a major impediment in production of field crops through their ability to compete for resources viz. Nutrients, light, space, water, air and their adverse impact on product quality. The losses due to weed infestation vary from crop to crop and depend mainly on type of weed species and their intensity. According to an estimate the losses due to weeds account nearly one third *i.e.*33%, diseases 26%, insects 20%, storage pest 7%, rodents 6% and other pests 8% of total crop losses[1]. Weeds are responsible for heavy yield losses to almost every important agricultural crop to the extent of complete crop loss under extreme conditions.

In India increased agricultural productivity is needed to meet the increasing needs of the growing population. Proper weed management technologies, if adopted can result in an additional crop production. As the weed problems are multi-pronged, a holistic multi-disciplinary integrated approach would be imperative. In this context, integrated weed management (IWM) may provide a more sustainable crop production by combating weed menace effectively, economically and ecologically.

Weeds are harmful in many ways, such as:

- Reduction in crop yield and production efficiency,
- Reduce produce quality,
- Adversely affect the soil productivity
- Weeds harbour insect pests and diseases,
- Obstruct the flow of water in irrigation channels and fields,
- Contamination of water bodies,
- Menace to human and animal health,
- Damage to industry and public utilities,
- Deterioration of aesthetics, and
- Reduction in farmers' income.

2. Classification of Weeds

2.1 According to Life Cycle:

2.1.1 Annual Weeds: They complete their life cycle within one year or one season.

a) Rainy Annuals: They appear with the onset of monsoon (June-July) and complete their life cycle before rainy season is over (Oct/Nov) *e.g.* Barnyard grass (*Echinochloa crusgalli, E. colonum*), False daisy (*Eclipta alba*), Crab grass (*Digitaria sanguinallis*) etc.

Echinochloa colona[2]

Echinochloa crusgalli[3]

Eclipta alba[4]

b) Winter Annuals: They complete their life cycle during winter season (Oct/Nov to Feb) e.g., Lambsquarter (*Chenopodium album*), Yellow sweet clover (*Melilotus indica*), Canary grass (*Phalaris*

minor), Blue grass (*Poa annua*), Sorrels (*Rumex crispus*) etc.

c) Summer Annuals: They complete their life cycle during summer season (March to June), majority of the Kharif season weeds grow during summer season in irrigated farming e.g., Spurge *(Euphorbia hirta),* Pig weed *(Amaranthus viridis)* etc.

d) Ephemerals: The short-lived annual weeds are called ephemerals e.g., Stonebreaker (*Phyllanthus niruri*). These weed completes their life cycle within a very short period of 2 to 4 weeks.

2.1.2 Biennial Weeds: They take at least two years or two seasons to complete their life cycle. They complete their vegetative growth in first year or season and produce flowers and seeds in the next year or season. e.g., Wild carrot (*Daucas carota*), Bold-leaf launaeae (*Launaea nudicaulis*) etc.

2.1.3 Perennial Weeds: They grow continuously for more than two years or several years. Perennial weeds are further classified as.

2.1.3.1 According to Root System: Depending upon the depth of root system perennial weeds are classified as

a. Shallow Rooted Perennials: Weeds having about 20 to 30 cm deep root system are called shallow rooted perennial weeds. e.g., Bermudagrass (*Cynodon dactylon*), Quack grass (*Agropyron repens*).

b. Deep Rooted Perennials: Weeds having about one meter or more deep root system. e.g. Nutgrass (*Cyperus rotundus*), Johnson grass (*Sorghum holepense*), *Acacia spp*., wild ber etc.

2.1.3.2 According to Mode of Reproduction:

a. Simple Perennials: Weeds which are reproduced mostly by seeds: e.g, *Lantana camara*, *Acacia spp.*, *Zizyphus spp*. etc.

b. Bulbous Perennials: Weeds which are propagated by underground parts like bulbs/ rhizomes/ tubers as well as by seeds e.g., Purple Nut sedge (*Cyperus rotundus*), Johnson grass (*Sorghum halepense*) etc.

c. Creeping Perennials: These weeds are spread by lateral extension of the creeping above ground stem or roots or by seeds. e.g., *Cynodon dactylon*, *Oxalis latifolia* etc.

Digitaria sanguinalis[5]

Chenopodium album[8]

Euphorbia hirta[6]

Amaranthus viridis[7]

2.2. According to the Habitat: Depending upon the place of their occurrence they can be grouped as under:

2.2.1 Weeds of cropped lands: e.g. *Phalaris minor, Chenopodium album, Echinochloa crusgalli*, etc.

2.2.2 Weeds of Pastures and grazing lands: e.g., *Parthenium hysterophorus, Cleome viscose* etc.

2.2.3 Non-Crop Land weeds: *Parthenium hysterophorus, Lantana camera, Cannabis sativa* etc.

2.2.4 Aquatic Weeds: e.g. *Eichhornia crassipes, Salvinia sp.* etc.

2.2.5 Plantation Weeds: *Cynodon dactylon, Parthenium hysterophorus*etc.

2.2.6 Lawn and garden weeds: *Tridex procumbence etc.*

2.2.7 Orchard and vineyard weeds: *Digiteria sanguinalis, Cynodon dactylon* etc.

Several weed species overlap in the above classification.

2.3 According to Nature of Stem:

2.3.1 Woody Weeds: These are the woody and semi-woody rough stem shrubs and are collectively called bush weeds, e.g., Acacia, wild ber, Lantana etc.

2.3.2 Herbaceous Weeds: These weeds have green and succulent stem and commonly occur on farm lands. e.g., Cock's Comb, Spurge, Carrot grass etc.

2.4 According to Association:

2.4.1 Season bound weeds: These weeds grow in a specific season in a year irrespective of the crop species cultivated. Some summer annuals or winter annuals are the examples of season bound weeds. In case of perennials, the period of their vegetative growth is taken as their growing season e.g. Johnson grass is a summer perennial weed whereas Creeping thistle is a winter perennial weed.

2.4.2 Crop bound weeds: Those weeds which usually parasitized the host crop e.g., Dodder (*Cascuta campestris*), Broomrape (*Orobanche aegyptiaca*) and Witch weed (*Striga angustifolia*) etc.

2.4.3 Crop associated weeds: These weeds are also crop specific but for different reasons, either due to requirement of specific micro-climate. e.g., *Cychorium intybus* and *Coronopus didymus* grown better in shady, cool and moist habitat of lucern and barseem etc. or due to mimicry e.g., wild rice in paddy fields and wild oat in wheat crop etc. Many of these weeds adjust by ripening before the harvest of main crop.

2.4.4 Contamination of crop seed by weed seed: Many weeds mature at the ripening time of crop and contaminate the crop seeds e.g. *Phalaris minor* seeds in wheat seeds etc. Also some weed seeds

Phalaris minor[9]

Melilotus indica[10]

Poa annua[11]

Rumex dentatus[12]

***Phyllanthus niruri*[13]**

Wild carrot (*Daucas carota*)[14]

***Launaea nudicaulis*[15]**

***Cynodon dactylon*[16]**

***Agropyron repens*[17]**

Also some weed seeds like wild onion and wild garlic contaminates onion and garlic seeds, respectively, due to their resemblance.

2.5 According to the Origin of Weeds:

2.5.1 Introduced/ Exotic / Alien Weeds/Anthrophytes: Many weeds move from the place of their origin by seeds or other parts to a new area and establish there and become introduces weeds and are called Alien or Anthrophytes.

1. Carrot grass (*Parthenium hysterophorus)* – U.S.A.
2. Silver leaf nightshade (*Solanu melaeagnifolium)*- North America
3. Lantana *(Lantana camera)*: Central America
4. Cockleber (*Xanthium strumarium*): America
5. Broomrape (*Orobanche spp.)*- Europe
6. Nutgrass (*Cyperus rotundus*): Eurasia
7. Water hyacinth (*Eichhornia crassipes)*– Tropical America
8. Johnson grass (*Sorghum helepense*)-Asia and southern Europe
9. Puncture vine (*Tribulu sterrestris*)- Southern Europe
10. Western Ragweed (*Ambrosia psilostachya)*- North America

2.5.2 Indigenous Weeds: Origin of majority of tropical weeds has been India e.g., Cock's comb, Spurge, Bermuda grass, *Amaranthus spp*. etc.

2.6 Facultative and Obligate Weeds: Weeds which grow primarily in undistributed or close communities but may sometimes escape to the cultivated fields are facultative weeds. It is also called Apophytes e.g., Cactus. Whereas, weeds which grow or occur primarily in cultivated field where the land is distributed frequently are known as obligate weeds. e.g., Field bind weed (*Convolvulus arvensis*).

2.7 Noxious Weeds: The weeds which are undesirable, troublesome and difficult to control are

called noxious weeds e.g. Nut grass, Bermuda grass, Carrot grass, Striga, Orobanche, Water hyacinth etc.

2.8 Objectionable Weeds: Weeds which produce seeds that are difficult to separate once mixed with crop seeds are called objectionable weeds e.g., mixture of Maxican poppy (*Argemone Mexicana)* seeds in mustard and wild onion (*Asphodelus tenuifolius*) in cultivated onion etc.

2.9 Industrials Weeds: Weeds invading areas around buildings, highway, railway lines, fence rows, electric and telephone pole bases etc. are called industrial weeds e.g., *Parthenium hysterophorus, Cynodon dactylon, Digiteria sanguinalis* etc.

***Cyperus rotundus*[18]**

***Sorghum halepense*[19]**

***Lantana camera*[20]**

***Oxalis latifolia*[21]**

***Cleome viscose*[22]**

***Eichhornia crassipes*[23]**

***Salvinia molesta*[24]**

Circium arvense[25]

Imperata cylindrica[26]

Saccharum spontaneum[27]

Cuscuta campestris[28]

Orobanche aegyptiaca[29]

Striga angustifolia[30]

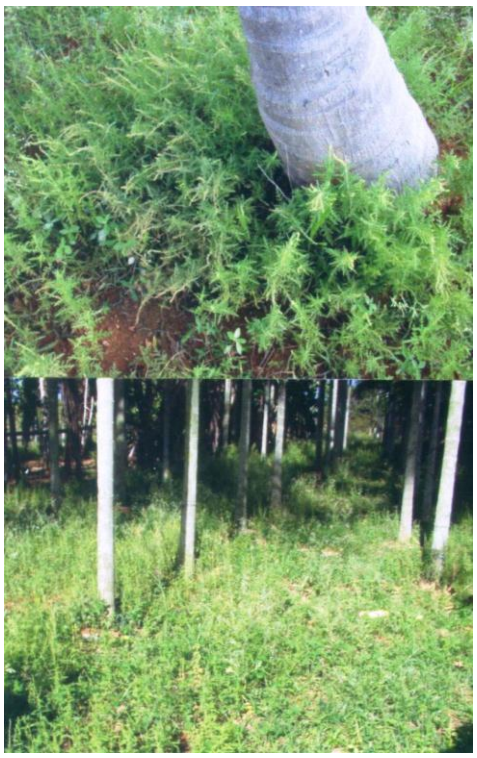
Argimone maxicana

Convolvulus arvensis[31]

Parthenium hysterophorus

Cassia tora

Achyranthes aspera[32]



Ambrosia psylostechia **a. plant and b. infested plantation crops in Tumkur district of Karnataka, India (Source: CIPMC, Bengaluru)**

2.10 Poisonous Weeds: Some weed plants are poisonous/allergic etc. e.g. *Parthenium hysterophorus*, Poison ivy (*Rhuss sp.*) etc.

3. Weed Ecology:

Weed Ecology is the interrelationship between weed and their environment. It is concerned with growth characteristics and adaptations that enable weeds to survive the changes in the environment. The environment includes climatic, edaphic and biotic factors and it determines the distribution, prevalence, competing ability, behaviour and survival of the weeds. Persistence of a weed is largely influenced by climatic, edaphic (soil) and biotic factors which affect its occurrence, abundance, range and distribution.

3.1 Climatic factors:

The important climatic factors of the environment that affect persistence of weeds are light, temperature, rainfall, wind and humidity.

Light intensity, quality and duration are important in influencing the growth, reproduction and distribution of weeds. Photoperiod governs flowering and time of seed setting and maturation and also has impact on the evolution of various ecotypes within a weed species.

Soil temperature affects seed germination and dormancy which is a major survival mechanism of weeds. The winter survival of underground parts (rhizomes, bulbs, tubers and roots) of perennial

weeds is very much dependant on their resistance to extreme temperatures in the soil.

Rainfall and water have a significant effect on weed persistence and distribution. The distribution pattern of rain is a determining factor in utilization of water supply by the plant, since water shortages at critical stages of growth are often responsible for failure of reproduction and survival.

Wind velocity, frequency and direction may also restrict or limit the occurrence and persistence of weeds. Wind plays a role in stabilizing oxygen and carbon dioxide balance in the atmosphere. It also modifies the transpiration losses from all the plants.

3.2 Soil factors:

Soil factors which influence weed persistence are soil water, aeration, temperature, pH, fertility level, and also cropping system.

The ideal pH for most plants to grow ranges from 6.2 to 7.3. This is the range where nutrients are most available for uptake by the roots of plants. Some weed species are characteristically 'alkali' plants, also known as basophiles (pH range 7.4 to 8.5) which can grow well in alkali soils, e.g., Alkaligrass (*Puccinallia* spp.) and quackgrass (*Agropyron repens*) Some weed species like *Cynodon dactylon*, *Digitaria sanguinalis* and *Borreria* spp. habitat only in acidic soils(pH range 4.5 to 6.5)called Acedophiles. A shift in soil pH, for example, towards acid side due to continuous use of ammonium sulphate as a nitrogen source could also cause a shift in the weed spectrum.

Several species of compositae and polygonaceae grow well in saline soils. These weeds serve as **indicator plants.** Some weed species like *Commelina benghalensis* thrive well in moist soil condition while the perennial grasslike *Imperata cylindrica*, *Agropyron repens* etc. persist even in drought conditions. Weeds like *Typha* spp. live only in waterlogged soils.

3.3 Biotic factors:

Plants and animals are the biotic factors that modify the growth in a variety of ways that affect weed persistence directly and indirectly. In a cropping situation, the major effects on weeds are those exerted by the crop as it competes for available resources like nutrients, light, space and water. Once certain weed species are introduced, their persistence in a given crop is determined largely by the degree of competition offered by the crop. The competitive ability of a weed and its persistence depends upon its vegetative habit, readiness of seed germination, rate of seedling growth and the extent and nature of root and top growth. Besides, the agricultural practices associated with the crop grown may encourage or discourage specific weeds. Crops that serve as host to parasitic weeds and crop-induced stimulants and toxin (allelopathy) are also example of other biotic factors.

Many factors influence the presence and abundance of weed species on groups of weeds in fields. Important factors include: method of sowing, soil moisture, crop rotation, type and amount of fertilizers applied, time of fertilizers application, cultivar, water management; crop management and weed control methods used. These factors influence the weed growth and subsequently the productivity and quality of crop produce. These factors are manageable to provide optimum crop stand and create microenvironment in favour of crop plants.

4. Survival Mechanisms of Weeds:

The seed is the primary means of survival mechanism of annual weeds. The vegetative plant propagules such as buds, rhizomes, tubers, bulbs and stolons offer an additional survival mechanism for perennial weeds. The major adaptations for survival of weeds include prolific seed production, survival of vegetative propagules under adverse conditions, seed dissemination and dormancy, and ability of seeds and propagules to resist any detrimental effects of environment. Of these, dormancy is probably the single most important characteristics of weed that enable them survive when crops cannot.

4.1 Seed Production:

Seed production is the sole means of propagation and survival of annual and biennial weeds while perennial weed are less dependent on this mechanism. A single plant of an annual weed can produce enough seeds in one season to cover an entire area of one acre with same weed species in the next year. For example, redroot pigweed (*Amaranthus retroflexus*), purslane (*Portula caoleracea*) and black nightshade (*Solanum nigrum*) produce approximately 196,405; 193,213 and 178,000 seeds per plant, respectively. Wild oats (*Avena fatua*) germinate at the same time, the crop was shown but shatter their mature seeds before crop harvest operations[33].

4.2 Seed Dissemination:

Most weeds are good travellers. They use various forces or agents to transport and scatter themselves from place to place. Of all the agents by which weeds are disseminated, wind, water, animals and man play important roles.

a. Wind: Many weeds seeds have modifications or adaptations e.g., saccate, winged comate, parachute and plumed which aid them in getting scattered by the wind. Seeds or small fruits with tufts of hair or wing-like appendages are carried by the wind over long distances; the lighter seeds may drift for miles. The achnes of dandelions,

thistles and species of compositae floating in the air on a windy day are a common sight. Similarly, the seeds of *Imperata cylindrica* and *Saccharaum spontaneum* are carried away by wind to faraway places.

b. Water: Many weed seeds are light or are covered with an oily film so that they float on the surface of water. Such seeds are frequently washed into the streams by surface run-off during heavy rains or they are picked up by overflowing streams and are carried to other fields lower down the valley.

c. Animals: Weed seeds are also disseminated by animals. Many seeds pass through the digestive tracts of animals without loss of viability. Birds also consume large quantities of weed seeds and scatter them in droppings. The dispersal of seeds in the form of incompletely digested materials passing through the animals is termed as 'endozoochory'. Seeds also stick to the fur, feathers and muddy feet of birds and animals and are carried from place to place. This method of dissemination is, however, not as important as the other means.

d. Man: Seeds of many weed species have specialized structure like hooks, spines, barbs and awns which tend to cling to man's clothing and foot wear or agricultural implements used by man. Fruits of *Tribulus terrestris* have sharp spines which cling to animals and man and get dispersed far and wide. *Achyranthus aspera* and *Chrysopoga aciculatus* have awns which get disseminated by sticking to man's clothing. Weed seeds are carried in packing materials and in soil and sand or gravel used in construction. Man often carries weed seeds of interest from one part of the country to the other and from one country to another. The movement of commercial seeds and grain is an important means of weed seed dispersal by man, e.g., widespread occurrence of *Phalaris minor* is because of its seeds contaminated the wheat grain imported in the 1960's.

4.3 Seed Germination:

Germination is a critical factor in the establishment of weed infestation. For germination, seeds of both crops and weeds must have adequate soil moisture, favourable temperature and a supply of oxygen. Weed seeds, however, possess a variety of special germination mechanisms adapted to changes in temperature, soil moisture, aeration, exposure to light, depth of burial of seeds etc. When conditions are unfavourable for germination, they can remain dormant or delay germination.

Seeds of many weeds require an exposure to light for germination. This is regulated by bluish-green protein pigment called phytochrome. Germination of the seeds of *Lactuca* (lettuce), *Xanthium* (cocklebur), *Lepidium* (pepper weed) and *Rumex* (sorrels) genera is controlled by phytochrome[33].

Many weeds germinate under aerobic conditions while some require anerobic conditions. Soil turn during ploughing and other land preparation operations exposes the seeds to light and induces germination.

Summer annuals favour higher temperatures for germination and one can see flushes of weed seedlings when temperature reaches at favourable levels. Winter annuals germinate at lower temperature and shorter days in the autumn and winter seasons. Some weeds can germinate freely throughout the year. Viability is an integral and major part of weed infestation.

4.4. Seed Dormancy:

Dormancy is a state in which viable seed fails to germinate in spite of favourable conditions of moisture, temperature and oxygen for plant growth. It is a survival mechanism of weeds. Further, when the conditions for germination are not favourable, seeds can become dormant. Seeds of weed species of Boraginaceae, Convolvulaceae, Cucurbitaceae, Leguminasae and Poaceae have long dormancy period often running into several years.

Types of seed dormancy:

a. **Inherent or innate dormancy:** It is due to the genetically controlled characters in the plant species, e.g., hard seed coats in *Setaria* and *Xanthium* spp.

b. **Induced dormancy:** It develops when the non-dormant seed becomes dormant after exposure to specific environmental conditions e.g., rise in temperature / CO_2 content in soil, low O_2 pressure, water logging etc. e.g. *Avena ludoviciana* seeds.

c. **Enforced dormancy:** It is a non-specific character and it develops when limitations of the habitat or environment prevent non-dormant viable seeds from germinating and germination occurs only when the limitations are removed e.g. deep placement of seeds, when such seeds restored to the top 3-5 cm of soil during ploughing, the seeds germinate. Absence of red light to some seeds also leads to enforced dormancy e.g., *Avena ludoviciana* seeds.

5. Weed competition:

The degree of weed competition is determined by the weed species infesting the area, density of infestation and duration of infestation. Weed species differ among themselves in their competing ability e.g., *Monochoria vaginalis* is more severe competitor than *Echinochloa crusgalli* in rice culture. Similarly, *Avena fatua* was found more competitive in wheat than *Setaria viridis*.

5.1 Critical period of crop weed competition

This is most important time period for Integrated Pest Management. The critical period for weed control is a period in the crop growth cycle during which weeds must be controlled to prevent yield losses. Critical period of crop weed competition observed in India w.r.t. various crops are given below:

Table 1: General Critical period of crop weed competition for different important crops grown in India[34 & 35]

Crops		Critical Period (DAS)*
A.	**Cereals**	
	Rice (Direct Seeded)	**15-45**
	Rice (Transplanted)	**30-45**
	Wheat	**30-45**
	Maize	**15-45**
	Sorghum	**15-45**
	Pearl millet	**30-45**
B.	**Pulses**	
	Pigeon pea	**15-60**
	Green gram	**15-30**
	Black gram	**15-30**
	Cowpea	**15-30**
	Chickpea	**30-60**
	Peas	**30-45**
	Lentil	**30-60**
C.	**Oilseeds**	
	Soybean	**20-45**
	Groundnut	**40-60**
	Sunflower	**30-45**
	Castor	**30-60**
	Safflower	**15-45**
	Sesamum	**15-45**
	Rapeseed-mustard	**15-40**
	Linseed	**20-45**
D.	**Commercial crops**	
	Sugarcane	**30-120**
	Potato	**20-40**
	Cotton	**15-60**
	Jute	**30-45**
E.	**Vegetable crops**	
	Cauliflower	**30-45**
	Cabbage	**30-45**
	Okra	**15-30**
	Tomato	**30-45**
	Onion	**30-75**
F.	**Spices**	
	Cumin	**20-40**

* DAS= Days after sowing/planting

6. Principles of Weed Management:

The principles that underline ecologically and economically viable weed management system are: (a) Adopting the weed management options that suits to the environment of the region, including soil, water, climate and biotypes present at the site and (b) Optimizing the use of cultural, biological, physical, mechanical and chemical resources for effective management of weeds. An important principle underlying long-term weed management is that weed seed banks decides the emergent weeds population, and therefore, seed banks must be managed at low densities to reduce the potential build-up of high weed populations.

7. Integrated Weed Management (IWM)

IWM is a science-based decision-making process that coordinates the use of environmental information, weed biology and ecology, and all available technologies to control weeds by the most economical means, while posing the least possible risk to people and the environment. Effective IWM combines preventive, cultural, mechanical, biological and chemical weed control methods in an effective, economical and ecological manner.

Weed management must aim at reducing the weed population to a level at which weeds occurrence has no effect on farmers' economic and ecological interests. By using different appropriate management practices against weeds, farmers have more options for controlling weeds, thereby reducing the possibility of escapes and weed adaptation to any single weed management tactic.

7.1 Preventive:

Weed prevention includes the measures to deny entry and establishment of new weeds in area. It includes (a) use of weed- free crop seeds , (b) seed certification (c) avoid contamination manure pits (d) prevent movement of weeds with other farm sources (e) by weed laws and (f) by quarantine laws.

7.2 Cultural

7.2.1 Crop rotations: Crop rotation is an important component of IWM. The choice and sequencing of crops affects long-term weed population dynamics, and consequently weed management. In traditional farming, rotations comprised of crops with different life cycles are a key component of weed management. Different planting and harvest dates among these crops provide more opportunities for farmers to prevent either plant establishment or seed production by weeds.

7.2.2 Soil Solarization:

Soil Solarization is a very simple technique of mulching the soil with transparent polyethylene sheet, especially when the soil has high moisture content during summer so as to trap more solar heat in the surface soil to raise the soil temperature to the level lethal to soil borne pests including weeds, pathogens and nematodes etc. During mulching

transparent polyethylene sheets should be buried on all the sides. Irrigation treatment should be given by flooding one day before mulching. It favours the soil heating and increases the mean maximum soil temperature by about 9^0C at 5 cm depth and 7^0C at 10-15 cm depth. Duration of 4-6 weeks of Soil Solarization is ideal for achieving the excellent results for rainy and winter seasons both and provides control of *Trienthema portulacastrum*, *Dactyloctenium aegyptium*, *Digera arvensis*, *Echinochloa colonum*, *Eleusine indica* in rainy season and *Avena ludoviciana*, *Phalaris minor*, *Chenopodium album*, *Rumex dentatus*, *Fumaria parviflora* in winter season[36]. In our country higher temperature prevails during the months of May-June. Simultaneously, there is very less cropping activities in these months at farmers' fields which provides a good opportunity for controlling the weeds, pathogens and nematodes etc. for a longer period by soil solarization which is an eco-friendly technique. However, soil solarisation should be selected on the basis of critical analysis of soil ecosystem as it contains several beneficial organisms which may also be affected.

7.2.3 Tillage: Tillage prior to crop establishment serves mainly to prepare a weed free seed bed. It eliminates established and emerged weeds prior to crop seeding and also moves weed seeds below the soil surface vertically, resulting in weed seed burial. It is suggested that an integrated weed management strategy involving summer ploughing and inter-crop cultivation are essential for effective weed control in direct-sown, flood-prone, lowland rice, in order to ensure higher N-use efficiency and crop productivity.

7.2.4 Stale seed bed: A stale seed-bed is one where a flush of weeds are destroyed before planting of any crop. Most weed seeds germinate from top 4 to 5 cm of surface soil. If a finally prepared seed-bed is withheld from planting and it contains adequate moisture in its top 4 to 5 cm of soil, a flush of young weed seedlings will grow on it in about a week's time. These weed seedlings can be destroyed either with shallow non-inverting tillage implement like, spike-tooth harrow /spring-tooth harrow / corrugated iron land roller / weeder-mulcher / sweeps. Depending upon the time available, one or two flushes of weeds can be destroyed in this manner before planting crops in the stale seed-beds. The main advantage of stale seed-beds is that crops germinate in weed-free environment. Stale seed-beds can be highly effective in controlling weeds in crops planted in a rain-free period with the help of irrigation e.g. berseem, lucern, potato etc. in India. However, in rainy season, an odd shower may make stale seed-beds too compact to plant crops without further tillage of the land. Besides, rainy weather will transplant many weed seedlings dislodged during the preparation of the stale seed-beds.

7.2.5Crop competitiveness: Using high yielding crop varieties which are more competitive against weeds in combination with other methods of weed control is one of the most economical approaches to attain optimal crop yield.

7.2.6 Crop mulching: Covering or mulching the soil surface can reduce weed problems by preventing weed seed germination or by suppressing the growth of emerging weed seedlings. Mulches can be made from a number of materials: a living plant ground cover (e.g. sugarcane trash), loose particles of organic or inorganic matter spread over soil, and sheets of artificial or natural materials laid on the soil surface.

7.2.7 Time of sowing: In some crops early sowing have the advantage in favour of crop to suppress the weeds, (e.g., Wheat) to compete with weeds that germinate later.

7.2.8 Row spacing: Row width may be reduced in some crops so that leaf canopy covers the soil faster and sheds out the weeds. However, closer spacing between rows should be balanced with keeping rows wide enough for hoeing/inter-culture operations.

7.2.9 Seed rate: Higher seed rate increase the crop plant stand and cover the soil early to shed out the weeds within rows, e.g. wheat, soybean etc.

7.2.10 Zero tillage: The use of zero tillage would also reduce the costs of seeding. In rice-wheat system, under zero tillage, the time taken between rice harvest and wheat sowing is considerably shortened and early sowing of wheat after rice results in better early crop growth to supress the weeds and increase the wheat yield.

If weed seed production was minimized during the growing season, weed seedling emergence in no-till would decline across the years compared with tilled systems as the surface weed seed pool in no-till will depleted more rapidly by emergence and mortality. Burial of weed seeds in soil by tillage favours persistence across time, thus leading to more weed seedlings in later years. Farmers can get additional benefits from this pattern of weed seedling emergence in no-till systems when it is combined with crop diversity in their rotations.

7.3 Mechanical/Physical:

To control the weeds at early stage of crop establishment hand weeding is being practiced by farmers in India since they initiated agriculture. It is most effective eco-friendly weed management practice for annual weeds. Hand weeding is ineffective against perennial weeds due to their regenerative capability. Mechanical management of

weeds consists of using machines or human made tools to suppress the weeds at the young stage of crops e.g. hand hoeing between rows of wheat, rotary-hoe / weeder-harrow in maize and soybean, inter-row cultivation (scuffling) by tractor drawn implements or bullock drawn cultivator in wider spacing crops like sugarcane etc. To manage the perennial weeds in non-crop areas, mower may also be used to cut down the weeds from soil surface. Repeated mowing of weeds may also be practiced to deplete the root reserves of the perennial weeds.

7.4 Biological:

The Biological control of weeds comprises the use of living organisms to attack the specific weed population to keep it below threshold level without significantly affecting desirable plants. It includes use of insects, pathogens, nematodes, mites, parasitic plants and competing plants. Besides these, certain fish carps and snails may also be employed for the control of aquatic weeds.

Historically, biological control methods have proved best on large infestation of a single weed species in range lands or in water bodies. Some outstanding examples of bio-control of weeds are the use of insect to control Pricklypear, *Opuntia vulgaris* (synonym *Opuntia monocantha*) naturally by cochineal insect (*Dactylopius indicus)in 1795* and later *Opuntia dillenii by Dactylopius tomantosus* (*D. punte*) after 1926; *Eichhornia crassipes*, aquatic weed by weevil (*Neochetina bruchi and N. eichhorniae*) since 1982, control of *Salvenia molesta*, aquatic weed by weevil *Cyrtobagous salviniae*since 1983-84[37 & 38].

Lantana camera, a bushy weed was also reported to be suppressed by tinged bug (*Teleonema scrupulosa)* after 1940, however, later this was declared unsafe and whole test culture was destroyed by FRI, Dehradun; limited suppression of Siam weed (*Chromomolaena odorata*) in South India by *Pareuchaetes pseudoinsulata* Srilanka strains in rubber plantations. Limited suppression of Crofton weed (*Ageratina adenophora / Eupatorium adenophorum / E. glandulosum*) by tephrited gall fly (*Procecidochares utilis*) in Nilgiris (Tamil Nadu), Darjeeling and Kalimpong areas. Limited success for control of *Parthenium hysterophorus* weed has been achieved by Chrysomelid beetle (*Zygogramma bicolorata*)[37]. There is also report of suppression of *Parthenium* weed by more competitive leguminous plant *Cassia tora,* which is less harmful than *Parthenium*. Unfortunately, biological weed control has not developed to the point to make appreciable impact on the production of agronomic crops.

However, the host specificity test and feeding potential of bio-control agents must also be taken into account while opting biological control of weeds.

7.5 Allelopathy:

The detrimental effect of natural release of chemical compound (exudates) of one plant on another plant(s) called allelopathy. These compounds include phenolic acids, coumarins, terpenoids and flavonoids. These allelopathic chemicals inhibits the seed germination or reduce the growth of other plants species. These compounds are released from the plants as a vapour or leaching from the foliage or exudates from the roots or during decomposition of the plant residues. Allelopathy in natural plant communities is a significant factor in maintaining the present balance among the various plant species. The allelopathy can be used to manage certain kind of weeds in the cropping system. e.g., root exudates of *Cirsium* sp. is deterimental to oat plants in the field; root exudates of *Euphorbia* spp. is injurious to the flex plants. Quack grass rhizome exudates is also reported to interfere with the uptake of nutrient by the Maize. Similarly, allelopathic effect of some crop plants may explore to manage the certain weed infestations in the field. e.g., isolate 1,3,7-Trimethylxanthine from *Coffeaarabica* have been reported to inhibit the germination of *Amaranthus spinosus;* and oat reported to have allelopathic effect on *Chenopodium* spp.[33]

7.6 Flame weeding

Flame weeding may be used for spot weeding. Gas presser and ground speed may be used to control the heat at which the weeds are killed. Exposure to heat for about one tenth of the second expands the water in the weeds & bursting of cell walls. In 3-4 days weeds become brown and dead. The best results are obtained on hot dry days.

7.7 Chemical herbicide

Use of chemical herbicide should be opted as a last resort for management of weeds in the field crops. The herbicides which are recommended by the CIBRC in a particular crop for control of specific weed species should only be advocated to the trainees / farmers. Herbicides are very selective and their dose, time of application, method of application, dilution in water, if any etc. should be adhere as per CIBRC claims for control of particular weed(s) in a particular crop. For the same label claims, if many herbicides formulations are recommended, the low a.i. dose herbicide may be preferred over higher a.i. dose herbicide. The details of CIBRC registered herbicides formulations recommended on various crops are available on the CIBRC website www.cibrc.gov.in.

7.7.1 Herbicide resistance

Continuous use of a particular herbicides in a particular field may led to development of

resistance in the weeds and may exuberate the weed problems further. For example, in rice–wheat cropping system of Punjab and Haryana *Phalaris minor* became the most dominant and problematic weed in wheat crop for which Isoproturon herbicides was continuously used by farmers for more than a decade during nineties and *Phalaris minor* developed resistance against isoproturon in these specific areas. However, among weeds of rice, such resistance against herbicides has not reported, yet, in India. To avoid the development of resistance in a particular weed against a particular herbicide, use of same herbicide year after year should be avoided rather different recommended herbicides should be used on rotation basis.

The Integrated Pest management suggests that use of chemical herbicide should be the last resort of weed management in any field crop / non-crop areas.

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Chapter-V

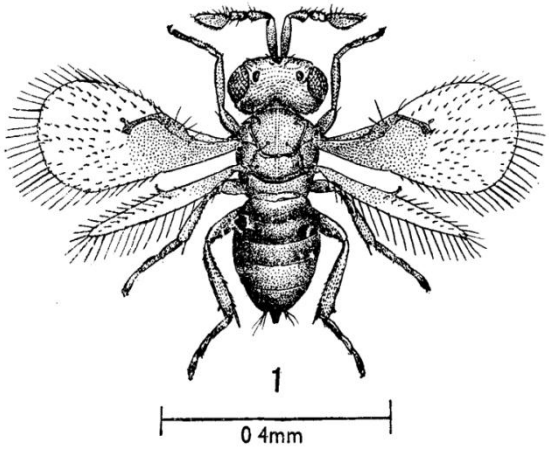
Laboratory Manual for Mass Multiplication of Bio-control Agents

MASS PRODUCTION OF *Trichogramma* sp. AND *Trichogrammatoidea* sp.

Introduction:

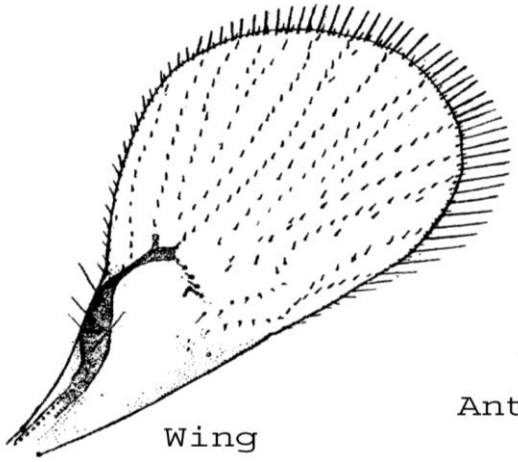
The genus *Trichogramma* and *Trichogrammatoidea* are cosmopolitan in distribution and parasitizing more than 200 species of Lepidoptera, Neuroptera, Diptera, Hemiptera, Coleoptera and Hymenoptera. Majority of *Trichogramma* and *Trichogrammatoidea* are primary parasitoids eggs of Lepidoptera (Tanwar et al. 2006). It is important for plant protection because of its wide spread natural occurrence and its success as biological control agent by mass releasing (Lenteren 2003). Since this parasitoid kills the pest in the egg stage itself before the pest could cause any damage to the crop and also that it is quite amenable to mass production in the laboratories, it has the distinction of being the highest produced and most utilized biological control agent in the world.

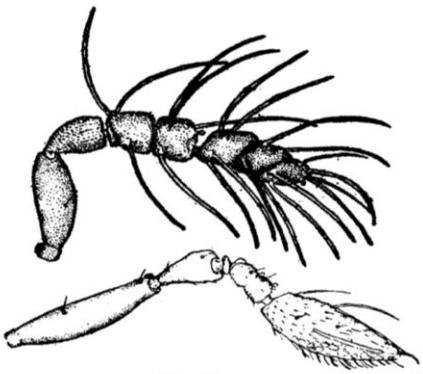
Trichogrammatidae includes the smallest of insects, ranging in size from 0.2 to 1.5 mm (Nagaraja, 1978). *Trichogramma* are difficult to identify because they are so small and have generally uniform morphological characters. Also, certain physical characteristics such as body color and the number and length of body hairs can vary with body size, season, rearing temperature and the host on which the adult was reared (Nagaraja, 1978).

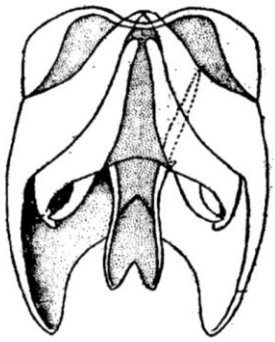


Taxonomy, Identification and Distribution:

A major advance in the systematics of *Trichogramma* was the discovery that characteristics of male genitalia can be used to identify species. This is the primary means of identification today, but body color, wing venation and features of the antennae serve as supporting characteristics (Nagaraja & Nagarkatti, 1970; Viggiani, 1971).


Wing

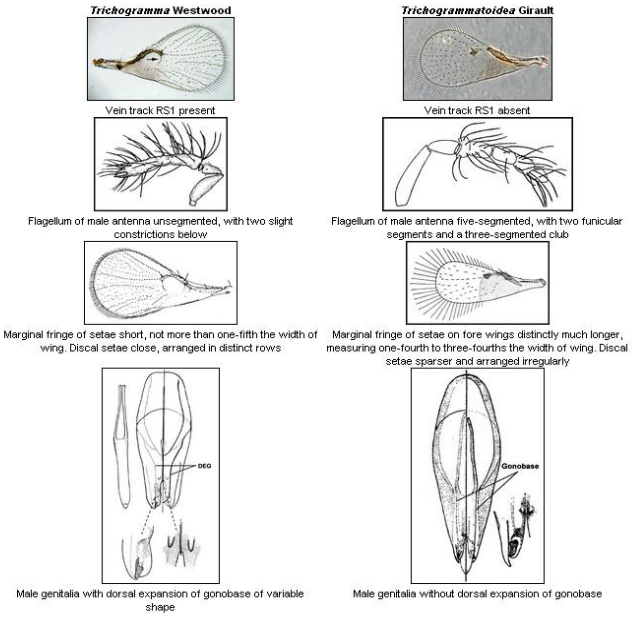

Antenna, Male & Female


Male Genitalia

Females cannot be identified with the same level of confidence, so collections submitted for identification must include males in addition to physical characteristics; studies of reproductive compatibility and mode of reproduction also have been especially valuable in identifying species (Girault, 1915; Pinto, 2006).

Distinguishing features between *Trichogramma* and *Trichogrammatoidea*

(Adopted from NBAII)



Kingdom: Animalia
Class: Insecta
Order: Chalcidoidea
Family: Trichogrammatidae

SN	species	Host	Common crop	Distribution
1.	*Trichogramma achaeae* Nagaraja & Nagarkatti	Egg of Lepidoptera	Field and orchard crop	Cosmopolitan
2.	*Trichogramma chilonis* Ishii	Egg of Lepidoptera	Field and orchard crop	Cosmopolitan
3.	*Trichogramma japonicum* Ashmead	Egg of Lepidoptera	Field and orchard crop	Cosmopolitan
4.	*Trichogramma pretiosum* Riley	Egg of Lepidoptera	Field and orchard crop	Cosmopolitan
5.	*Trichogramma toidea bactrae* Nagaraja	Egg of Lepidoptera	Field and orchard crop	Cosmopolitan

Biology of *Trichogramma* and *Trichogrammatoidea*

(Adopted from Tanwar *et al.*, 2006)

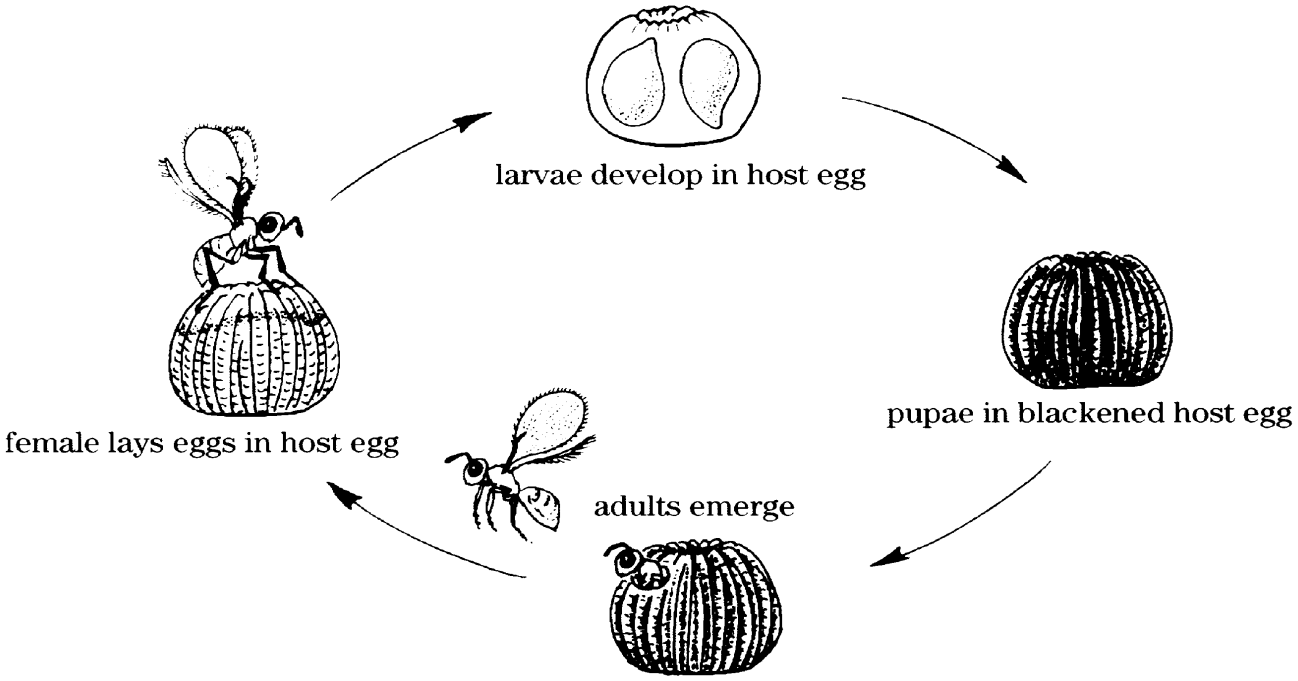
The development of all *Trichogramma* spp. is very similar. Being an egg parasite, the female drills a hole through the chorion and deposits its eggs within the egg of the host. The internal pressure of the egg forces a small drop of yolk out of the oviposition hole. Females feed on this yolk, which increases their longevity and under laboratory conditions a female parasitizes from one to ten eggs per day or from ten to 190 during her life.

Egg: The number of eggs laid per host egg may vary from 1 to 20 or more depending upon the size of the host egg. However in sugarcane, in which moth borer eggs are small, generally 1 or 2 parasites develop per egg. Large females parasitize more eggs than smaller females. A female parasitoid can distinguish already parasitised eggs, thereby avoiding superparasitism or multiple-parasitism under natural conditions. Fecundity varies from 20 to 200 eggs per female according to the species, the host, and the longevity of the adult. Eggs in the early stages of development are more suitable for parasite development.

Larva: During the 3rd instar (3 to 4 days after the host egg was parasitized) dark melanin granules are deposited on the inner surface of the egg chorion, causing the host egg to turn black. This is an invaluable diagnostic character for distinguishing them from unparasitised eggs.

Pupa: Larvae transform to the inactive pupal stage.

Adult: The wasps emerge from the pupae and escape the host egg by chewing a circular hole in the egg shell. The black layer inside the chorion and the exit hole are evidence of parasitism by *Trichogramma*. The egg, larval and pupal stages of *Trichogramma* at 28 ± 20C are completed in about 1 day, 3 to 4 days, and 4 to 5 days respectively.



Thus, the life cycle is completed in 8 to 10 days, but it may be prolonged at lower temperatures or hampered at very high temperatures. The adults are short lived (6-8 days). Mating and oviposition take place immediately after emergence. The sex ratio is generally 1:1.

Material required for Mass rearing:

1. *Corcyra* cage
2. Oviposition cage
3. Moth collecting device
4. Sterilization chamber
5. Cleaning device
6. Consumable material

Mass production

Different species and strains of *Trichogramma* typically prefer different host eggs and crop habitats and have different searching abilities and tolerance to weather conditions. Efficacy is improved by selecting the most effective and adapted species or strain for the specific crop / pest situation. In the laboratory the parasitoids are multiplied on *Corcyra* eggs. The eggs laid by the *Corcyra* moths are collected and sieved to remove the moth scales etc. The pure eggs thus obtained are exposed to ultra-violet light in UV chamber to kill the host embryo but at the same time permit parasitisation.

UV Chamber

Laminar flow

The quantity of the sterilized eggs is assessed in a measuring cylinder volumetrically. The eggs in volume of 0.5cc is then sprinkled uniformly over a 144 gsm (chart paper) card. Label information on

the manufacturer, species of the parasitoid, date of parasitization and expected date of emergence are given. The size of the card is 03cm x 18cm for 0.5cc of eggs.

A coat of 10% gum is applied on the grids and the eggs are sprinkled uniformly in a single layer with the aid of a tea strainer.

The excess eggs pasted are removed by gently passing a shoe brush over the card after sufficient air drying under fan.

Figs.___. Corcyra rearing cage outer view and Inner view

The egg cards are placed into polythene bags of suitable size and the nucleus card of *Trichogramma* are introduced in it. The easiest way to accomplish this is to place a piece of '*Tricho* egg card' containing parasitized eggs that are ready to yield the adults and to hold them in subdued light for 2 to 3 days.

The emerging parasites readily parasitize the fresh eggs. The parasitoid - host ratio is adjusted accordingly to 1:6 get effective parasitism.

The parasitized eggs in the *Tricho* Card turn back in 3 or 4 days and the adult parasitoids emerge in 8 to 10 days from the date of parasitization.

The parasitized eggs in which the parasitoids in the larval or pupal stage (i.e. before or after turning black) can be stored in the refrigerator (at 50C) for about 3 weeks without any loss in emergence.

Precautions

Poor quality of mass reared *Trichogramma* can result in control failures. The artificial conditions of mass rearing can select for genetic changes that reduce the effectiveness of the *Trichogramma* in the field. Such rearing conditions include rearing multiple generations on unnatural host eggs, the absence of plants, crowding and interference, rapid generation time, and failure to rejuvenate genetic stock. Except for obvious problems such as lack of adult emergence or wing deformities, growers and pest consultants cannot detect poor quality *Trichogramma* prior to release. Commercial suppliers are responsible for maintaining desirable characteristics necessary for good performance in the field. Production colonies should be periodically replaced with individuals from a stock culture maintained on the natural or target host. Suppliers also should assess the per cent host egg parasitization, adult emergence, and the sex ratio of emerged adults to be sure they are within acceptable standards. Standards for established cultures on *Corcyra* are 95±5 per cent egg parasitization, 90±5 per cent adult emergence, and a sex ratio of 1 to 1.5 females per male.

Field release: The parasitoids are released in the pharate stage or when few adults begin to emerge from the host egg during the evening hours. The cards are cut into bits neatly along the grids with least damage to the eggs and stapled beneath the foliage in the upper canopy level. To maximize the field parasitization it is recommended to release the parasitoids is as many locations as possible. Recently scientists are beginning to advocate the release of cards @ 1/5m row length.

Maintenance of history sheet

Accurate information is needed on the history of individual basins.

The following information is furnished.

1. Date of egg infestation
2. Date of preparation of feed
3. Source of egg
4. Expected date of adult emergence
5. Daily collection of moths
6. Problems encountered with the basin during production

Production of Host:

Corcyra cephalonica commonly called as rice meal moth or rice moth is a pest of stored foods, *viz.*,cereals, cereal products, oilseeds, pulses, dried fruits, nuts and spices. Many of the natural enemies mass-bred in the laboratory for use in field against crop pests are dependent on either egg or larval stages of *Corcyra* due to the simple reason that it is easier and cheaper to produce natural enemies on different stages of *Corcyra* than on their original hosts.

Procedure

1. Preparation of rearing basins

The basins used for *Corcyra* multiplication are thoroughly cleaned and sterilized with formaldehyde. Whenever the trays are emptied after a cycle of rearing, they have to be cleaned preferably to 2 per cent formaldehyde and returned to storage until further use. On reuse the cleaning steps are repeated.

2. Preparation of Jowar medium for *Corcyra*:

a. The required quantities of jowar grains are coarsely milled and broken into 2-3 pieces in a milling machine. The broken grains are heat sterilized at 100^{o}C for 1 hour to eliminate the residual population of stored product insects *viz., Rhyzopertha dominica*, *Sitotroga cerealella*, *Tribolium castaneum* and fungal contaminants. Upon sterilization the grains are cooled under fan in a clean area. The grains are then transferred to basins @ 2.5 kg/basin.

b.Groundnut kernel in required quantity is broken using a pounding machine or a mechanical blender (domestic mixer). Then 100 g of the broken kernel is transferred to each basin and the contents are hand mixed thoroughly.

c. Dry yeast (Bakers) and wettable sulfur is added @ 5g/ basin and the contents are mixed thoroughly. A spray of 10 ml of 0.01-0.05% streptomycin sulfate and mixing of the contents follows this. This medium is used for rearing *Corcyra* larvae.

d. The number of basins required for egg infestation is calculated and the medium is prepared accordingly.

3. Preparation of *Corcyra* eggs:

The primary source of *Corcyra* eggs is reputed laboratories, commercial producers for bulk preparation. If it is intended to begin the production with nucleus colony, the adult moths can be collected from warehouses where the food materials are stored.

a. The eggs used for building up the colony of *Corcyra* have to be free from contaminants like the moth scales and broken limbs and not exposed to UV light.

b. The collections of overnight laid eggs are measured volumetrically to ascertain the number of trays that can be infested with eggs. A cc of eggs is known to contain approximately 16000 – 18000 eggs.

4. Infestation of medium with eggs

The overall production scheme involves initial infestation of the medium with *Corcyra* eggs in desired quantities. This is accomplished by sprinkling the freely flowing eggs on the surface of the medium in individual basins. Per basin 0.5 cc eggs of *Corcyra* is infested. The basins are carefully transferred to the racks.

5. Handling the trays during larval development

The larvae that hatch out in 3-4 days begin to feed the fortified joar medium. At this stage, light webbings are noticed on the surface. As the larvae grow up they move down. During this period the larvae are allowed to grow undisturbed in the trays.

Handling of adults: The adults begin to emerge in 28-30 days after infestation of the eggs. The adults can be seen on the inside the cage. They are either aspirated with mechanical moth collector or collected with specimen tubes. The whole operation is carried out in a tent of mosquito net. This prevents the large-scale escape of the moths, which if uncontrolled can migrate to the storage area and spoil the grains stored by laying eggs. Workers involved in the collection of moths should wear face moths continuously to avoid inhalation of scales. The moths collected are transferred to the oviposition drum @ 1000 pairs per drum at a time. The oviposition drums of size 30 x 20 cm are made of plastic. The drums rest on tripod frames with legs of height 5cm. The bottoms of the drums are provided with wire meshes that enable collection of eggs. The walls of the drums have two vents (ventilation holes) opposed to each other. The vents are again covered with wire mesh. The lids of the drums have handles besides slots for introducing the moths and adult feed. The oviposition drums filled in a day are maintained for four to seven successive days for egg collection after which are emptied and cleaned for next cycle of use.

The adults are provided feed containing honey solution. The adult feed is prepared by mixing 50 ml honey with 50 ml water. The feed is stored in refrigerator and used as and when required. Piece of cotton wool tied with a thread is soaked in the solution and inserted into the drum through the slot at the top. From a basin, moths can be collected upto 90 days after which the number of moths emerging dwindles down and keeping the basins is not economical for the producer.

Handling of eggs: The moths lay the eggs in large numbers loosely. The scales and broken limbs are also found in larger quantities along with the eggs. They cause potential hazard to the workers after years of working in *Corcyra* laboratory. To minimize the risk of scales freely floating in the air, the oviposition drums are placed on sheets of filter paper in enamel trays which trap effectively the scales. Sets of several oviposition drums are kept in ventilated place near an exhaust fan to enable the workers comfort. Daily morning the oviposition drums are lifted up and the wire-mesh bottoms are cleaned gently with a shoe brush so that the eggs and remnants of scales and limbs settled on the mesh are collected along with those on the filter paper. The collections are cleaned by gently rolling the eggs on filter paper to another container. Then they are passed to sieves in series and finally clean eggs are collected. The eggs are quantified in measuring cylinders and used for building up the stocks and natural enemy production. About 100 pairs of adults produce 1.5 cc of eggs in 4 days laying period inside the oviposition drums. From each basin an average of 2500 moths are collected. Hence from each basin 18.00 – 20.00 cc of eggs can be obtained in 90 days.

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Mass production of *Bracon hebetor*

Introduction:

Bracon hebetor is a common gregarious ecto – larval parasitoid. There appears to be two strains of the parasitoid, one attacking field pests and the other stored product pests.

Among the hosts recorded are *Corcyra cephalanica, Dichocracis punctiferalis, Eublemma olivacea, Hellula undalis, Ostriniaicius kashmirica, Helicoverpa armigera and Opisina arenosella of which the O. arenosella* is the important host.

Parasitism is observed throughout the year, it ranged from 26.2 to 26.7% during the peak period of *O. arenosella* infestation.

Kingdom: Animalia
Class: Insecta
Order: Hymenoptera
Family: Braconidae

SN	Species	Host	Crop	Distribution
1.	*Bracon hebetor*	Mostly larval parasitoids of lapidoptera	Field and orchard crop	Cosmopolitan

Production procedure:

B. hebetor is reared on *C. cephalonica* at wide ranging temperature and fluctuating relative humidity.

Pairs sorted out from freshly emerged brood are caged in specimen tubes (8 x 2.5 cm). Under laboratory conditions it is easy to rear.

Fifth instar caterpillars of *C. cephalonica* of similar size are provided for oviposition and the parasitized larva removed daily from the tubes and maintained separately.

The parasitoids are fed with 50% honey provided as tiny droplets on wax-coated paper strips.

B. hebetor completes its total developmental period in 7-12 days. The egg, larval and pupal period are completed in 1-2, 2-4 and 3-7 days respectively.

The females start laying eggs 2-5 days after emergence on partially paralyzed host caterpillars.

The paralyzed larvae (not receiving the eggs) die within 3-5 days. Female parasitoids feed on host's haemolymph.

The eggs are laid singly or in groups of two to eight. A female is capable of laying 229 eggs (142-345) on 14-32 host caterpillars during its life span of 20-63 days, the daily average being 2-27, and

laid maximum number of eggs during the first ten days of oviposition period.

A single host larva supports the development of 11 eggs and 9 larvae of the parasitoid. The preoviposition period is 3 days, oviposition period 22-55 days and post oviposition period 1-8 days.
The fertile female lives for 20-63 days. *B. hebetor* complete its developmental period on larvae of *Corcyra cephalonica* in 8.6 (7-10) days.

Oviposition period lasts for 13 (5-22) days. The mean fecundity is 72 (13 – 148). Females live for 24-53 days. Egg viability is 92% and adult emergence 81%. Male to female ratio is 5:1.

Precautions:

To avoid wastage, the surplus parasitoids could be stored in the cocoon stage for one month in the refrigerator.

The coccons are kept in a clear plastic jar (19x9 cm) for emergence and provided with raisins as food.

Segregate the mite (*Pediculoides ventricosus*) infested cultures of the host insect immediately.

Mass production of *Goniozus nephantidis*

Introduction

Goniozus nephantidis is the most widely used parasitoid of *Opisina arenosella*. It is a sturdy gregarious larval or prepupal ectoparasitoid.
The female practices maternal care of eggs and larvae. The host larvae are parasitized and the parasitoid even feeds on host body fluid.

The parasitoid is also capable of suppressing the population by merely stinging and paralyzing 1st – 2nd instar larvae. *G. nephantidis* is the most common and effective parasitoid of late instars caterpillars of *O. arenosella* in several parts of the country.

The parasitoid is being mass multiplied and released in Karnataka, Kerala and several other states.

Kingdom: Animalia
Class: Insecta
Order: Hymenoptera
Family: Bethylidae

S N	Species	Host	Crop	Distribution
1.	*Goniozus nephantidis*	Larval ectoparasitoid of the coconut black-headed caterpillar, *Opisina arenosella*	Field and orchard crop	Andhra Pradesh; Karnataka; Kerala; Tamil Nadu etc.

Production procedure:

The parasitoid is multiplied on *Corcyra cephalonica* larvae in diffused light. A pair of parasitoid is introduced in tube (7.5 x 2.5 cm).
The adults are provided honey in the form of small droplets on wax coated paper. After a pre-oviposition period of six days one healthy last instar larva is provided in a vial.

The larvae parasitized and containing eggs of *G. nephantidis* are removed regularly from the vials till the death of the female. Such larvae are kept in accordion type strips of paper in plastic boxes which are covered by muslin cloth.

Considering the fecundity as 20-50, the female is capable of parasitizing 6-7 larvae in three oviposition spells each separated by 4-5 days.

The life cycle of the parasitoid is completed in 10-14 days (incubation 24-36 hrs, larval feeding 36-48 hrs, prepupal stage 48-60 hrs and cocoon period 48 to 56 hrs + resting adult inside the cocoon 108-128 hrs).

Mass production of *Chelonus blackburni*

Introduction

Chelonus blackburni is introduced from Hawaii. A parthenogenetic egg-larval parasitoid, *C. blackburnii* has a fairly wide host range but in India the common meal moth *Corcyra cephalonica* and potato tuber moth *Phthorimaea operculella* have often been used for multiplication of this parasitoid.

Kingdom: Animalia
Class: Insecta
Order: Hymenoptera
Family: Braconidae

S N	species	Host	Crop	Distribution
2.	*Chelonus blackburni*	Mostly egg larval parasitoids of Lepidoptera	Field and orchard crop	Cosmopolitan

Production procedure

A set of 100, 0-24 hr old eggs of *Corcyra* (not exposed to UV) are pasted to 5 x 5 cm card. This

card containing eggs is exposed to 30 *C. blackburnii* adults in a 1.5 l container.

The plastic container has windows with plastic mesh for aeration. Two cotton swabs, one soaked in 10% honey solution and the other in drinking water are also placed inside from the side opening which is closed tightly with a cloth covered cotton plug.
The egg card after exposing to *C. blackburnii* for 24 hrs is removed and placed on 500 g sterilized Pearl millet medium. In 30 days time, adults start emerging from the cocoons formed in the Pearl millet medium after completing development on Corcyra larvae. The adults live for 25 days and their fecundity is about 400 eggs.

Mass production of *Trichoderma viridae*

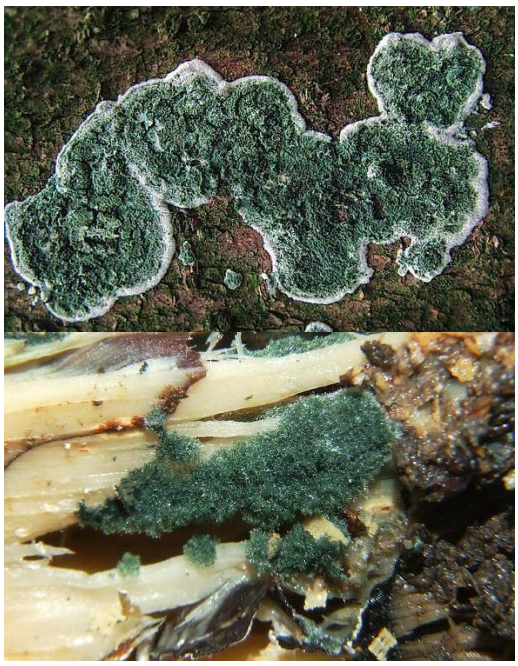
Introduction

Trichoderma viridae besides other species of the genus, is an omnipresent saprophytic fungus. Its colonization in rhizosphere of crop plants renders long time protection against diseases, improved growth of plants besides imparting resistance. Such species as *T. harzianum, T. hamatum, T. lignorum* and their biotypes have the most biological and commercial importance. *Trichoderma biofungicides* are highly effective against the powdery mildew, the grey and the white rot, the mildew and other diseases. Active components of biopesticides made from this fungus are their spores, mycelium and metabolites. *Trichoderma* is able to suppress more than 60 species of pathogens (Pythium, Botritis, Phoma, Sclerotinia, Fusarium, Ascochyta, Alternaria, etc.) on different plants (cucumbers, tomatoes, cabbages, peppers, various ornamentals, cereals and grain legume crops).

Taxonomy, Identification and distribution

Kingdom: Fungi
Class: Sordariomycetes
Order: Hypocreales
Family: Hypocreaceae
Genus: *Trichoderma*
Species: *viridae*

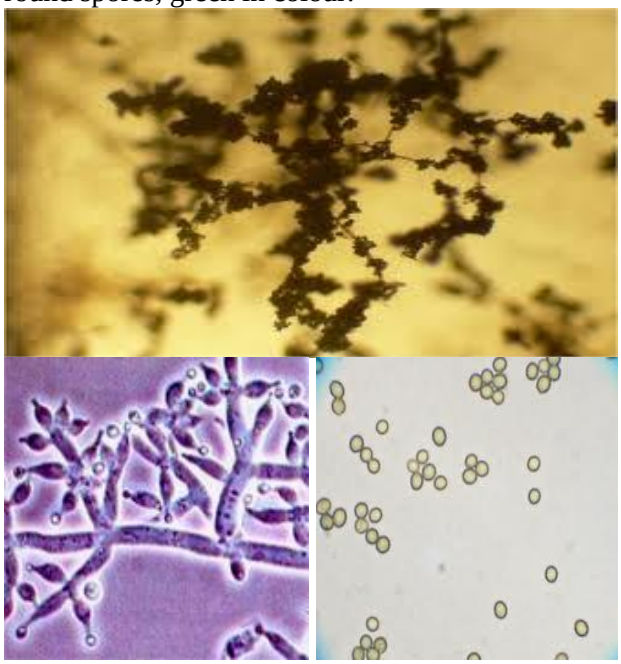
Trichoderma viridae is widely distributed in the world and found in substantial numbers in nearly all agricultural soils and in other environments such as decaying wood, etc.



Trichoderma viridae colonies on dead wood and other organic matter

Biology of biological control agents

Trichoderma viridae form hyaline, branched and septate hyphae with profuse conidiophores and conidial formation. Conidiospores are ovoid to round spores, green in colour.



Conidiophores and conidiospores under microscope

Among their other activities, they grow tropically toward hyphae of other fungi, coil about them in a lectin-mediated reaction, and degrade cell walls of the target fungi. This process (mycoparastitism) limits growth and activity of plant pathogenic fungi. Mycoparasites produce cell wall-degrading enzymes, which allow them to bore

holes into other fungi and extract nutrients for their own growth. In the process of development *Trichoderma* synthesizes a lot of antibiotics (gliotoxin, viridine, trichodermin, etc.).
Mass production of biological control agent
Production on PDA

Materials required

Potato	200 gm
Carboxy Methyl Cellulose	5 gm/kg
Distilled Water	1 litre
Streptocyclin	03.5 gm
Agar-Agar	20 gm
D-glucose	20 gm

Method

1) Take 200gm healthy Potato, wash with distilled water, cut it into slice and keep in a beaker
2) Add 400 ml distilled water and boil it for 45 min. till starch oozes out from potato slices
3) Filter the content through fine muslin cloth and save the effluents
4) Add 20 gm Agar-Agar, 20 gm D-glucose and heat it till Agar-Agar solubilizes
5) Make the required volume 1 litre by adding distilled water
6) Transfer the content in a conical flask and close the mouth with cotton plug, wrap the mouth with Aluminium foil and tie with thread
7) Autoclave it for 15 min at 15psi
8) After completion of Autoclaving process, remove the conical flask and allow it to cool
9) Add 0.5gm Streptocyclin per litre of media and mix it properly
10) Transfer the media into test tube/Petri Dishes under Laminar Air Flow Chamber
11) When media get solidified, use sterile inoculation needle and under spirit lamp inside LAFC
12) Take the Trichoderma culture from mother stocks with sterile inoculation needle and inoculate it into fresh PDA media
13) Close the mouth and seal the petriplate with Parafilm
14) Keep the petriplate inside Incubator/at room temperature

Trichoderma viridae colony on PDA

Production on broken maize, sorghum or finger millets

Material required

Sorghum/ Maize broken grains, distilled water, hot air drier, autoclavable bags/ conical flasks, autoclave, D-Glucose/ Jaggery, Yeast extract, Cotton plugs, Streptocyclin, inoculation needle, muslin cloth, grinder, talcum Powder, carboxy methyl cellulose

Procedure

1) Take 100 gm broken maize/sorgum grain, wash with distilled water properly and keep in hot air drier for 15 min.
2) Transfer the grains from drier to autoclavable polybag/conical flask
3) Add 100ml distilled water, 1gm D-glucose/Jaggery and 0.5gm Yeast extract
4) Mix the content by proper shaking and plug the mouth with cotton plug and tie with thread
5) Autoclave the polybag/conical flask for 15-20 minute at 15psi
6) After Autoclaving, remove the polybag/conical flask and allow the content to cool
7) Add 0.01gm streptocyclin solution and shake
8) Under LAFC, perform Inoculation of *Trichoderma* culture by using sterile inoculation needle
9) Plug the mouth with cotton and tie with thread and keep the inoculated polybag/conical flask inside incubator/at room temp for 6-7 days.
10) After full growth of mycelia, remove the material in a plastic tray , spread with spreader and cover with thin black muslin cloth and allow it to shade dry for 5-6 days
11) After complete drying, grind the *Trichoderma* material to powder using grinder
12) Prepare the 1000 Gm ready to use formulation as below:
Trichoderma material 100gm + Talcum Powder 900gm + Carboxy methyl cellulose 5gm

Application

Suspend *Trichoderma viride* material in sufficient water (500g/100L) to achieve uniform application. Apply at the rate of 100-200 g per cubic metre (loose) of greenhouse potting mix, soil or planting beds. *Trichoderma viride* can be applied through low pressure watering nozzles such as fan nozzles or other watering systems (drip system) after filtering with filters. Agitate to maintain suspension. For best effect, treat potting mix several days before use for seeding or transplants.

For bulbs & Ornamentals: Dip bulbs in *Trichoderma viride* suspension (100 g/L) prior to planting.

Dose

Soil application: 5 kg /ha along with any organic fertilizer (without pathogenic contaminants). Seed treatment: @ 4-5 gm per kg of seeds as per standard wet treatment. Seedling treatment: @ 100 g/l prior to planting.

It is necessary to incorporate the conidia of *Trichoderma* every 10–15 days for the control of the mentioned phytopathogens.

Two to three applications in vegetables ornamentals and 4-5 applications in lawns and landscape crops are recommended. Applications during early stages of plant growth protect the plant during critical stages of development.

Precaution

There are some limitations for the application of Trichoderma biofungicides. At first they are preventive only because biofungicides are usually not able to control the diseases, which have already developed. The fungicides containing Trichoderma are effective at temperatures more than 14°C (the optimal threshold of development is observed at 24–28°C). Use of the conidial form of the fungicide makes the application independent on the conditions of relative air humidity.

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Mass production of *Beauveria bassiana*

Introduction

Beauveria bassiana is a mitosporitic and aggressive entomopathogenic fungus, attacking a wide host range of insects at larval or adult stages. It was the first recorded entomopathogen in world (Bassi 1835). It attacks all stages of insects of all groups. Some of the pests of economic importance , which can be targeted for control through *B. Bassiana* are *Helicoverpa armigera*, *Spodoptera* spp., *Odontotermis* spp, *Chilo infuscatellus*, *Ideoscopus* spp, *Bemisia tabaci*, etc. (Bambawale et al 2005).

Taxonomy, Identification and distribution of common species

Valid scientific name: *Beauveria bassiana* (Balsamo) Vuillemin

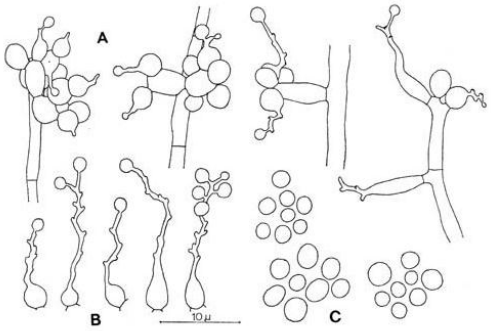
Kingdom: Fungi
Class: Sordariomycetes
Order: Hypocreales
Family: Clavicipitaceae
Genus: Beauveria
Species: *bassiana*

B. Bassiana occurs world wide and has one of the largest host lists among imperfect fungi. It occurs as a ubiquitous saprophyte in soil (Bambawale et al 2005). The pathogen is of cosmopolitan nature. The hosts include mainly Lepidoptera, Coleoptera, Hemiptera, Diptera and Hymenoptera.

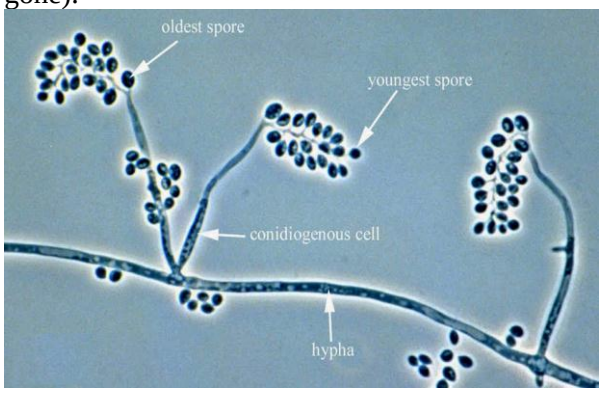
Biology of *Beauveria bassiana*

Beauveria bassiana is an anamorphic fungus with septate hyaline mycelium. Colonies appear white in cultures or tufts of white mycelium bearing masses of powdery spores. Conidiophores bear conidia in acropetal succession. The conidiospores are tiny, measuring only a few microns. A spore is produced at the tip of the mother cell and the growth of the mother cell ceases. A new growing point initiates just below this terminal spore, grows past it and a second spore is produced at a higher level. This uses up the new growing point and a third growing point is then initiated just below the second spore. Every time a spore is produced the hyphal tip is used up and a new growing point is produced. In this way a succession of spores is produced with the youngest spore at the tip (= i.e acropetal succession) and the spore head gets longer and longer. When all the spores are dislodged the spore-bearing tip of the conidiogenous cell has a zig zag appearance and is referred to as a rachis (this

term is also used for the seed head in wheat when all the seeds are gone).



Beauveria bassiana
conidiophores (A-B) and conidia (C)



Microphotograph of *Beauveria bassiana* conidiophores

Beauveria bassiana in action as entomopathogen The action of *B. bassiana* on insects begins from the penetration of spores in a body cavity through dermal coat (cuticle). High humidity or free water is essential for conidial germination and infection establishes between 24 and 48 hours. Having penetrated in a body the spores germinate in hyphae, then a mycelium overgrows from which conidia split off. Having proved in the body the conidia begin to circulate in hemolymph. Mycelium gradually fills up the whole body of the insect. In the beginning muscular tissue is affected. Fungus growth continues until all the tissues are destroyed. The infected insect may live for three to five days after hyphal penetration and, after death, the conidiophores bearing conidia are produced. The fungus can form conidiophores, which rupture the cuticle and the envelope of a dead larva. The affected insect is covered with white, wadded coating (conidiophores). Then it is observed spore maturation, and mass sporulation begins. The spores are tiny, measuring only a few microns. Colonies appear as tufts of white mycelium bearing masses of powdery spores burst out through the body parts of infected insects.

Beauveria bassiana attacking insects

The effectiveness of Beauveria bassiana depends very much on climatic conditions, the methods of application and doses. The best hydrothermal conditions for the development of B. bassiana are: a temperature of 25–28°C, a relative air humidity of 80–90%.

Mass Production of *Beauveria bassiana*

Material required

Base material, e.g. parboiled rice, autoclavable bags of appropriate size, cotton plugs, thread, pressure cooker, stove/ hot plate, 5% Sodium hypochlorite solution, UV Lamp, Syringe for inoculation, Streptocyclin.

Procedure

Soak parboiled rice in water for 30 min

Drain & fill in polythene bags @ 1 kg equally distributed in 5 bags (200 g/ bag)

Close mouth of bag with cotton plug & tie with thread

Place about 15 bags (3 kg material) in the pressure cooker and cook with some quantity of water. After 3 whistles reduce the flame and allow heating for 15 min.

Clean working table with 5% sodium hypochlorite solution & switch on the UV lamp.

Take out the bags & remove water adhering to the sides with tissue paper and place in a clean tray.

Switch off UV lamp. Place the bags on working table and allow further cooling

Sterilize the syringe along with the rice bags

Holding the liquid mother culture bottle above the flame, remove plug and add 2 drops of surfactant and 10 drops of antibiotic & shake well

Draw 15 ml liquid culture in the sterilized syringe and inject into the bag through cotton plug [Care to avoid puncturing of bag]

Mix well, spread rice grain within bag and place in racks for incubation

After 2 weeks incubation, on profuse sporulation, gently crush the lumps into individual grains

Cut open bags from sides, spread the culture within the bag and allow drying for 4-5 days

After complete drying, separate the spores by sieving

Allow drying on the work bench for about 3 days. A good culture with 1 kg rice yields about 40 g dry conidia in two or 3 sievings at weekly intervals. Sieving should be done under hood to avoid inhalation of spores.

Pack the dried spores in laminated aluminium foil and store in freezer compartment of a refrigerator.

Precaution

The fungus has been kwon to cause infection of nasal passage in human, therefore caution is necessary (Amerika Singh et al 2005).

Maintenance of quality

Formulations should contain conidia of *Beauveria bassiana* at a concentration of 2.3 x 107 spores per ml or at least 5 x 108 spores per gram. Viability of the spores is determined by culture on nutrient agar and counting the colonies formed. Efficacy is checked by bioassay with an appropriate insect.

Field release

Beauveria bassiana is released as foliar sprays against borers, whitefly, thrips, aphids, mealybugs and a range of soft-bodied coleopteran, homopteran and heteropteran pests. Application rates depend upon the crop and the pests to be controlled.

Dose

The normal application rate on commodity crops is 750 to 1000 ml of product per hectare, for ornamentals under cover or outdoors 24 to 80 ml per 10 litres and on turf and lawns 32 to 96 ml per 100 square metres.

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Production of the nuclear polyhedrosis virus of *Helicoverpa armigera*

Introduction

In India, *Helicoverpa armigera* is of major importance damaging a wide variety of food, fibre, oilseed, fodder and horticultural crops. The nuclear polyhedrosis virus of *H. armigera* (HaNPV) is currently used for the management of *H. armigera* on chickpea, cotton, pigeon pea, tomato and sunflower. Mass production of Nuclear Polyhedrosis Virus (NPV) on commercial scale is restricted to in vivo procedures in host larvae which are obtained by

- Field collection from cotton, pigeon pea and chickpea – *H. armigera*
- Mass culturing in the laboratory in semisynthetic diet – *H. armiger*
- Some small scale producers use field – collected larvae for mass production of NPV in spite of the following constraints.
- Collection of a large number of larvae in optimum stage (late IV / early V instars) is time-consuming and can be expensive in terms of labour and transportation costs.
- Wild populations of insects may carry disease causing organisms like microsporidians,cytoplasmic polyhedrosis virus, stunt virus and fungal pathogens which will affect both virus production and quality.
- Introduction of wild strains of NPV resulting in quality control problems.
- Transportation of a large number of larvae with cannibalistic behaviour will be a difficult task.

- Parasitized larvae collected from the field will die prematurely yielding little virus.

Rearing of larvae in the natural host plant will involve frequent change of food at least once a day during the incubation period of 5-9 days increasing the handling time and hence the cost. In order to reduce the cost, field collected larvae are released into semi synthetic diet treated with virus inoculum. Mass culturing of insects in semi synthetic diet involves high level of expertise, hygiene and cleanliness.

Composition of semi-synthetic diet for *H. armigera*

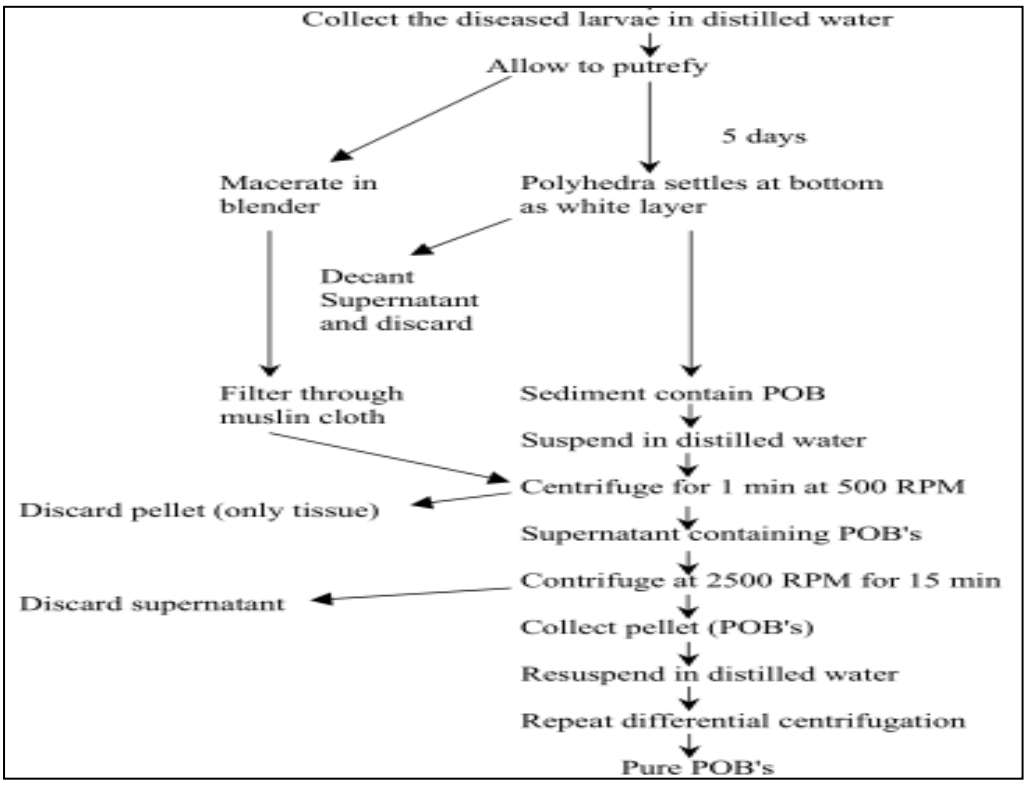
Component	Quantity
Chickpea flour	100g
Yeast	30g
Wesson's salt mix	07g
Methyl Paraben	02g
Sorbic acid	01g
Ascorbic acid	03g
Agar	13g
Vanderzint vit. Solution	08ml
Streptomycin sulphate	40mg
Carbendazim	675mg
Formalin	02ml
Water	720ml

Procedure for larval diet

1. Boil agar in 360ml of water, until completely dissolved.
2. Cook chickpeas in 360ml of water for 10 minutes and then transfer to a mixer.
3. Add the agar to the chickpea flour and mix
4. The Wesson's salt mix, methyl paraben, sorbic acid and yeast are added together and homogenised for 5 minutes.
5. After the died has cooled to about 70^{o}C, add the vitamin mix, ascorbic acid, carbendazim, formalin and streptomycin sulphate, and mix the died well for 5 minutes.
6. While still warm, dispense the diet into the rearing vessels, place (preferably) in laminar flow hood and leave to cool and solidify.
7. Cover the diet with clingfilm and store in a refrigerator until use.

Production procedure

The NPV of *H. armigera* is propagated in early fifth instar larvae. The virus is multiplied in a facility away from the host culture laboratory. The dose of the inoculum used is 5 x 10^5 polyhedral occlusion bodies (POB) in 10 ml suspension. The virus is applied on to the semisynthetic diet (lacking formaldehyde) dispensed previously in 5 ml glass vials. A blunt end polished glass rod (6 mm) is used to distribute the suspension containing the virus uniformly over the diet surface. Early fifth instar stage of larvae are released singly into the glass vials after inoculation and plugged with cotton and incubated at a constant temperature of 25^{o}C in a laboratory incubator. When the larvae exhausted the feed, fresh untreated diet is provided. The larvae are observed for the development of virosis and the cadavers collected carefully from individual bottles starting from fifth day. Approximately, 200 cadavers are collected per sterile cheese cup (300 ml) and the contents are frozen immediately. Depending upon need, cadavers are removed from the refrigerator and thawed very rapidly by agitation in water.



Processing of NPV

The method of processing of NPV

requires greater care to avoid losses during processing. The pellet finally collected is suspended in distilled water and made up to a known volume, which is necessary to calculate the strength of the POB in the purified suspension.

Mass production of *Cryptolaemus montrouzieri Mulsant*

Introduction:

Cryptolaemus montrouzieri Mulsant was introduced into India in 1898 by Newport from Australia mainly for the control of *C. viridis*, but has established on many species of mealybugs and scales. It has been successfully used for the control of guava mealybugs, *F. virgata*, guava green shield scale, *Chloropulvinaria psidii* (Maskell), grapevine mealybug, *M. hirsutus*, coffee mealybug, *Planoeoeeus citri* (Risso), etc.

Taxonomy, Identification and distribution of common species

Kingdom: Animalia
Class: Insecta
Order: Coleoptera
Family: Coccinellidae

SN	species	Host	Crop	Distribution
1.	*Cryptolaemus montrouzieri* Mulsant	Mealy bugs, soft scales and some other soft bodied sucking pests	Citrus, coffee, grapes, mango, several other fruit crops, ornamentals and cotton	Widely distributed in India.

Biology of *Cryptolaemus montrouzieri* Mulsant

In the laboratory, the life cycle is completed in approximately 30 days. The premating and preoviposition periods are about 5 and 10 days respectively. The oviposition is about 10 days. Eggs are laid from late evening to early morning. They are pale yellowish white, the surface being smooth and shiny. It is oval to cylindrical, both the ends beings smoothly rounded. Incubation period ranges from 5 to 6 days but extended in winter months. Viability of eggs is 90 to 100 per cent.

The newly hatched grub is sluggish but becomes active after 3 to 4 hours. The tiny grub is pale greyish with white lines across the body along intra segmental regions. These white lines become prominent after few hours and white wax strands develop after a day. The grub has four larval instars, and the larval stage occupies about 20 days. They feed on all stages of mealy bugs. Duration of first, second, third and fourth instar grubs are 3-4, 4, 4-5-7-8 days respectively. Grownup grubs are entirely covered with white wax strands. When the grub is disturbed, it exudes a yellow fluid from the dorsal surface of the body for defensive purpose. The prepupal period is 2 to 4 days when it suspends feeding activities.

The pupal period varies from 7 to 9 days.

The adult spends about one day in the pupal case before it emerges. It is covered with a white powder like substance for a day. The male could be distinguished from the female by the colouration of first pair of legs. The first pair of legs in the case of male is brown and the latter two pairs being black, whereas in the female all the three pairs are black. Male to female ratio is 1 : 1. Adults are also known to attack and feed the mealy bugs. Longevity of adults ranges from 50 to 60 days and the fecundity is about 200-220 eggs.

Mass production of *Cryptolaemus montrouzieri* Mulsant:

Material required:

Large sized cages, stainless steel stands, red pumpkins infested with mealy bugs, wax, carbendazim, burlap, camel hair brush, etc.

Procedure:

After 15 days of infestation of pumpkins with bugs they are exposed to a set of 100 beetles for 24 hrs. After exposing, the pumpkin is kept back in a cage as described for under production of *M. hirsutus*. The beetle during the period of exposure feed on mealy bugs as well as deposits their eggs singly or in groups of 4-12. The grubs are visible in such cages within a week of exposure to beetles. The young grubs feed on eggs and small mealy bugs but as they grow they become voracious and feed on all stages of mealy bugs. For facilitating the pupation of grubs dried guava leaves or pieces of papers are kept at the base of each of the cages. The first beetle from the cages starts emerging on 30th day of exposure to *C. montrouzieri* adults. The beetles are collected daily and kept in separate cages for about 10-15 days to facilitate completion of mating and pre-oviposition. The beetles are also

fed on diet containing agar powder (1 g), sugar (20 g), honey (40 cc) and water (100 cc). The adult diet is prepared by boiling sugar in 70 cc of water, adding 1 g agar, diluting 40 cc honey in 30 cc of water and adding to the sugar and agar mixture when it comes to boiling point. The hot liquid diet is kept on small white plastic cards in the form of droplets which get solidified on cooling. Such cards containing adult diet can be fed not only to *C. montrouzieri* but also to many other species of coccinellids. From each cage about 175 beetles are obtained.

The emergence of the beetles is completed within 10days. Beetles can also be reared on *Corcyra cephalonica* eggs but empty ovisacs of *Planococcus citri* are to be kept for inducing egg laying by the beetles. *Cryptolaemus* is most active when the weather is sunny. A temperature of 22 to 25°C and a relative humidity of 70 to 80 % are optimal for egg laying. The beetle is not active when temperature drops to 16°C (diapause). Temperatures above 33°C confuse the beetles when looking for prey.

Precaution:

All due precautions should be taken to avoid scarcity of food for the grubs to avoid cannibalism by grubs. All the pumpkins showing signs of rotting should be properly incinerated.

Maintenance of quality:

Sufficient food should be provided to the predators. A temperature of 22 to 25°C and a relative humidity of 70 to 80 % are optimal and should be maintained. Absence of live product contaminants, maintenance of purity and viability of *C. montrouzieri* are of great importance in order to maintain the quality. Breeding with field collected wild population after every third generation is advisable. Sex ratio of 1:1 to be maintained during release.

Transport:

Cryptolaemus montrouzieri is supplied as adults packed per 25 or 500 pieces in plastic tubes with filter paper as carrier. If necessary, they can be stored for a short while at a temperature of 10-15°C and RH >85%

Field release:

Before releasing in the field in the endemic areas, moderate to severely infested plants are marked. The plant trunks are ringed one foot away with a band of 5% diazinon granules 24 hrs before the release of the beetles; this stops the patrolling of ants on the trunk at least for 3 days.

Dose:

The general release rate recommended is 10 beetles or 50 grubs per infested plant and can be varied depending on the crop and the extent of infestation.

For the suppression of *Rastrococcus iceryoides* Green and other coccids including *Nipaecoccus viridis* infesting mango 20-25 adults of *C. montrouzieri* are released on each of the infested mango tree.

When applying *Cryptolaemus* in greenhouses, introduce 2 to 3 adults/m².

Maintenance of history sheet:

The following information is furnished.

1. No. of adults released per cage.
2. Date of release.
3. Different developmental periods.
4. Expected date of adult emergence.
5. Collection of adults.
6. Problems encountered with the culture during production.

Biology of Host (*Maconellicoccus hirsutus*):

The grapevine mealy bugs occur throughout the year on grapevine. The bugs are found the leaves, shoots, nodes, bunch and loose bark in the vine. The adult females are pinkish and covered with a mealy coat. The fecundity per adult is 350-500 eggs. The orange coloured eggs hatch in 5-10 days and the crawlers migrate and settle on places that support their food requirement. The crawlers

become sedentary as they advance in age. The multiplication rate of the bugs is higher in summer months and life cycle gets prolonged during cooler months.

Host production:

Material required:

Large sized cages, stainless steel stands, red pumpkins, wax, carbendazim, burlap, camel hair brush, etc.

Procedure:

Colony establishment

The colonies of the mealy bugs are established from field collection initially. Guava plantations, vineyards, croton plants, citrus and pomegranate gardens are good reservoirs of the mealy bug populations. From them a primary colony under quarantine is established separately in the lab utilizing the quarantine facility. During this period the colony is purified to obtain mealy bug population free of attacks by parasitoids and scavenging ants.

Culture maintenance

The mealy bugs are cultured on pumpkin (red) in the laboratory. It is very difficult to maintain the colony on the natural host plants. The selection of pumpkin is critical for successful development of mealy bugs. Fleshy pumpkins with intact peduncle and deep ridges and furrows of weight 2.5 kg devoid of wounds and mouldy patches are used for multiplication of the bugs. The pumpkins are soaked in carbendazim 0.5% for 1 min. and shade dried. The cut ends and wounds are plugged with molten wax. Along the furrows burlap is provided to facilitate settling of the crawlers. The pumpkins are placed in large sized cages over stainless steel stands. The cages are set up in ant proof conditions as the mealy bugs secrete honey dews which attract ants invariably.

Ovisacs of healthy adults are collected and placed on fresh pumpkin in the laboratory individually. From them, the eggs are allowed to hatch and multiply. The crawlers move along the burlap and settle. In a month time, the mealy bugs begin to smother the entire surface of the pumpkin. From this stock, subsequent colonies are established. When the colony is in active growth period with breeding females, the ovisacs are collected with the help of camel hair brush and transferred to fresh pumpkins prepared as above.

Precaution:

During the mass production care is taken to avoid fungal invasion. The cages, steel ware and burlap used are sterilized using common bleach. Used pumpkin fruits with symptoms of mould invasion are disposed of immediately. The cages are to be set up in ant proof conditions. The culture should be free from parasitoid infestation.

Maintenance of quality:

Culture should be a pure one, free from live product contaminants, parasitoids, diseases, etc.

Maintenance of history sheet:

The following information is furnished.

1. Date of infestation with mealybug.
2. Scientific name of the species.
3. Source of mealy bug.
4. Different developmental periods.
5. Problems encountered with the culture during production.

Reference:

Leppla, N.C, Bloem, K. A. and Luck, R.F.2002. Quality control for mass-reared arthropods. Proceedings of the Eighth and Ninth Workshops of the IOBC Working Group on Quality Control of Mass-Reared Arthropods.pp 171.

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Mass production of *Chilocorus nigrita* (Fabricious)

Introduction:

Chilocorus nigrita (Fabricius) is a voracious predator of many immobile or slow-moving Homoptera, especially diaspine scales like sugarcane scale, *Melanaspis glomerata* (Green), California red scale, *Aonidiella aurantii* (Maskell), Green shield scale, *Chloropulvinaria psidii*, coconut scale *Aspidiotus destructor* and coffee green scale, *Coccus viridis* (Green) and also aphids, aleyrodids, psyllids, pseudococcids, margarodids, coccids, etc. (Samways, 1984). This predator is encountered naturally in several ecosystems where diaspine scales are abundant. It is native to the Indian subcontinent and has been introduced into USA for the biological control of *Aonidiella aurantii* (Maskell) on citrus, into Mauritius and Hawaii for *Aspidiotus destructor* Signoret on coconut and for other scale insects in several other countries.

Taxonomy, Identification and distribution of common species

Kingdom: Animalia
Class: Insecta
Order: Coleoptera
Family: Coccinellidae

SN	species	Host	Crop	Distribution
1.	*Chilocorus nigrita* (Fabricius)	Scale insects, aphids	Sugar cane, citrus, mango.	Widely distributed in India
2.	*C. subindicus* Booth	Diaspine scales	Coconut, areca nut, coffee, black	southern India, Lakshadweep Islands.
3.	*C. circumdatus* Schonherr	Diaspine scales	Coconut, areca nut, coffee, black	southern India

Biology of *Chilocorus nigrita* (Fabricious):

Length 3.2-4.0 mm; width 2.9-3.9 mm. Form subrounded, almost hemispherical and strongly convex. Head dull orange yellow. Pronotum dark pitchy brown to black in middle, paler on sides, anterolateral flaps orange yellow. Elytra black, shiny, with fine punctations. Ventral side including legs and inner margins of elytral epipleura orange yellow to yellowish brown, outer margins of epipleura pitchy brown to black. Male genitalia and female spermatheca as illustrated. Larva greyish, oval in outline with numerous spiny, branched protuberances on dorsal side.

Studies on biology of *Chilocorus nigrita* (Fab.) revealed that total developmental period of *C. nigrita* was shortest (26.13 days) on *Melanaspis glomerata* (Green) when compared with *Aspidiotus destructor* (Sign.) and *Hemiberlesia lataniae* (Signoret). The fecundity and longevity of *C. nigrita* were found to be comparatively high with maximum suitability index (2.638) when reared on *M. glomerata*. Adults of *C. nigrita* was voracious than grub stage and each adult required 1195.65 ± 23.01, 1183.33 ± 52.04, 1095 ± 67.27 number of *M. glomerata, A. destructor* and *H. lataniae* while a total of 244.41 ± 4.89, 228.73 ± 6.52 and 219.73 ± 3.26 number of scale insects were consumed by grub in its all four stages, respectively. Old grubs consumed more scales than the young grubs.

Mass production of *Chilocorus nigrita:*

Material required:

Cages, Honey-agar diet, plastic plates, cotton pads, sugarcane setts inoculated with scale insects, etc.

Procedure:

The predator can be multiplied on several diaspine scales (*Aonidiella aurantii* (Maskell), *Hemiberlesia lataniae* (Signoret) and others. But is easily multiplied on *M. glomerata.*

C. nigrita adults are released @ 100 per unit (cage or tray). Honey-agar is provided as supplementary food for adults.

Honey-agar is prepared by adding 1000 cc water, 10 gm agar agar powder, 200 gms sugar and 400 gms honey. The sugar is first added to 750 cc of water, once the sugar dissolves, add agar agar. The honey is mixed with 250 cc of water, when

sugar agar solution starts boiling honey solution is added and the mixture boiled for about half a minute. The hot adult diet is removed from the fire and small drops arranged on plastic plates or hard board or thick cards. On solidifying the diet is offered to the beetles.

The first beetles start emerging from the multiplication cage in about 30 days time and the beetles continue to emerge for about a week. The adults are collected daily and the days collection kept in separate cages, 100 beetles each (A) where breeding of progenies has to continue, and 1000 beetles (B) each from where eggs are obtained for field release. The beetles start egg laying within 5 to 11 days. For field release (B) the eggs are obtained on cotton wool cut into squares, about 4 cm x 4 cm and laid over the feeding sites. The females readily oviposit on such pads.

Thirty five 4 cm x 4 cm pads of the cotton are placed in each egg obtaining adult beetle cage (B) containing 1000 adults each and the pads with eggs removed every day. Each pad contains about 40 eggs (usually more).

This beetle can also be cultured on Latania Scale, *Hemiberlesia lataniae* (Signoret) on pumpkins.

Precaution:

Only 24 hr old eggs should be dispatched, so that by the time the shipment reaches the destination the eggs tend to hatch thus precluding egg parasitism in the field.

The procedure adopted for producing *C. nigrita* could also be used for producing *Pharoscymnus horni* Weise, *Sticholotis madagassa* and *Rhizobius (Lindorus) lopthanthae* (Blaisdell) and other similar beetles feeding on diaspine scale insects. Many diaspine scales can also be multiplied on pumpkins. The larvae of certain coccinellid beetles particularly of *R. lophanthae* tend to develop cannibalism in the absence of suitable stage and sufficient number of the hosts (these conditions normally do not develop in commercial production units where the production assembly is geared to give a definite turn out to meet the demand of the farmers).

Maintenance of quality:

Sufficient food should be provided to the predators. Absence of live product contaminants, maintenance of purity and viability of the species are of great importance in order to maintain the quality. Breeding with field collected wild population after every third generation is advisable. Strict maintenance of hygienic condition.

Transport:

The egg containing pads in hard card board boxes or adults packed in plastic tubes with filter paper as carrier are readily transported to the release site.

Field release:

The pads are placed or distributed throughout the sugarcane field by locating the heavily infested focal points within the field. The hatching grubs start feeding on the scale insects present in the vicinity and generation of the beetle develops in the sugarcane field. The beetles of the second generation which have developed in the sugarcane field disperse to feed on the population of the scale insect in the area.

Dose:

In endemic areas 100 spots per hectare are selected and at each spot 10 pads containing eggs are placed over the scale infested canes. In areas where adult beetle release is preferred, release 1500 beetles of *C. nigrita* and /or *Pharoscymnus horni* Weise per hectare at the first appearance of the pest. In Citrus**:** Ten adults / tree.

Maintenance of history sheet:

The following information is furnished.

1. No. of adults released per cage.
2. Date of release.
3. Different developmental periods.
4. Expected date of adult emergence.
5. Collection of adults.
6. Problems encountered with the culture during production.

Biology of Host (*Melanaspis glomerata* (Gree) (Diaspididae: Hemiptera):

The adult female is soft bodied, small, disc like, eyeless and degenerated. Males are winged and short lived. The scales (protective covering) of males are usually oval and oblong whereas in case of females it is round and circular. Females are ovoviviparous and never come out from her scale covering.

Adult males after coming out from under surface of the scale begin to move on the internodes in search of the female. After copulation female produces nymphs. Female is ovoviviparous and produces about 400 nymphs during her life time. The nymphs that hatch out inside body come out through the genital aperture of the female. The young tiny yellowish nymph which comes out from beneath the mother scale crawls on cane surface and settle down on one of the internodes. Nymphs insert its proboscis into the plant tissues and suck

the cell sap. Once it settles down never moves from that spot. Nymph secretes a protective covering (scale) around it-self inside which metamorphosis occurs and adults are formed. The pest remains active almost throughout the year and under South-Indian conditions 4- 9 overlapping generations are completed in a year. The males complete their life cycle in about 20-25 days whereas the females take about 40-45 days for the same purpose.

Host production:

Material required:

Sugarcane setts, formalin, Benlate, paraffin wax, plastic trays, piece of mosquito net, black cloth, cement pots, cages, iron frames.

Procedure:

M. glomerata is ovoviviparous in reproduction. Six to eight month old healthy canes without any fissures and with undamaged buds of susceptible varieties like Co671, Co4133 and Co740 are selected for culturing the scale insect. The cane pieces are cut into 40-45 cm pieces bearing three internodes each. The sets are surface sterilized with formalin and 2% Benlate, shade dried and the cut ends dipped in moulten paraffin wax to prevent fungal infection and drying. The sets are arranged in plastic trays (30X40X6.5 cm) the inner sides of which are painted black or in breeding cages 0.3 sq meter. The initial culture of the host insect is started by bringing cane scrapings bearing full grown scales from heavily infested fields. The scrapings are places over a piece of mosquito net helping them spread over prepared cane pieces horizontally. The trays are covered with a black cloth and fastened with a string. Similarly the cages are covered with black cloth to obtain better setting and good culture by creating dark conditions. After 48 hrs, the sets are rotated to ensure uniform infestation. Once pure culture is established, the subsequent infestation is obtained by placing the freshly prepared canes in close contact with well infested canes. After 72 hrs they are planted by removing the wax from one side in sterilized moist sand in cages or in cement pots 62X62X30 cm containing jungle soil. The planted sets are covered with polyvinyl cages 20 cm in height and 15 cm in diameter and covered with lid on which window is cut and fixed with net to provide aeration.

The inoculated cane sets are placed in specially designed iron frames (45X35X20 cm) containing 5X5 cm squares and sterilized water. The water in the tray is changed once in two days.

Precaution:

The initial culture of *M. glomerata* collected from the field should be freed from all natural enemies. The sets used for producing should be disinfected and waxed before use. The shriveled sets if any should be discarded. Only highly susceptible cane varieties should be used to produce healthy scale insects in required quantity.

Maintenance of quality:

Culture should be a pure one, free from live product contaminants, parasitoids, diseases, etc.

Maintenance of history sheet:

The following information is furnished.

1. Date of infestation with scale insect.
2. Scientific name of the species.
3. Source of scale insect.
4. Different developmental periods.
5. Problems encountered with the culture during production.

Reference:

Leppla, N.C, Bloem, K. A. and Luck, R.F.2002. Quality control for mass-reared arthropods. Proceedings of the Eighth and Ninth Workshops of the IOBC Working Group on Quality Control of Mass-Reared Arthropods.pp 171.

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Mass production of *Scymnus coccivora* Ayyar

Introduction:

Species of *Scymnus* are well known in tropical areas as predators of scale insects, mealybugs, aphids and other soft-bodied arthropods. *Scymnus* species occur widely in tropical areas and have been used in many classical biological control programmes. According to CABI BIOCAT database, more than 50 species of this genus have been introduced in various countries to control 27 species of homopteran pests belonging to 6 families, mainly Pseudococcidae (48.1%), Diaspididae (14.8%), Aldegidae (14.8%), Aleyrodidae (11.1%), Aphididae (7.4 %) and Coccidae (3.7%). *Scymnus* spp. have been used most successfully in biological programmes against mealybugs (Pseudococcidae) and woolly aphids (Adelgidae).

Taxonomy, Identification and distribution of common species

Kingdom: Animalia
Class: Insecta
Order: Coleoptera
Family: Coccinellidae

SN	species	Host	Crop	Distribution
1.	*Scymnus coccivora* Ayyar	Mealybus, Scale insects, aphids, whitefly, mites, etc.	brinjal, cotton, guava, mango, mulberry, teak, citrus, grapevine, etc.	Widely distributed throughout India.
2.	*brunnescens*	Mealybugs, aphids, mites, midges, white fly, etc.	brinjal, cotton, guava, mango, mulberry, teak, citrus, grapevine, etc.	Widely distributed throughout India.
3.	*nubilus* Mulsant	Mealybugs, aphids, mites, midges, white fly, etc.	brinjal, cotton, guava, mango, mulberry, teak, citrus, grapevine, etc.	Widely distributed throughout India.
4.	*latemaculatus* M otschulsky	Aphids, mealy bugs, scales.	brinjal, cotton, guava, mango, mulberry, teak, citrus, grapevine, etc.	Widely distributed throughout India.
5.	*castaneus* Sicard	Aphids, Mealybug.	brinjal, cotton, guava, mango, mulberry, teak, citrus, grapevine, etc.	Widely distributed throughout India.

Biology of *Scymnus coccivora* Aiyar

Length 1.70-1.90 mm, width 1.20-1.30 mm. Form elongate oval, moderately convex. Ground colour pale golden yellow to yellowish brown, with dark purplish brown markings on elytra. Elytra with an hour glass-shaped longitudinal marking in basal half, which sometimes appears as two distinct markings; two small circular spots present in posterior half; elytral pattern variable, sometimes with only posterior spots present or uniformly yellowish brown, completely devoid of markings. Antenna 11-segmented. Prosternal intercoxal process with a pair of carinae, broader towards

posterior. Postcoxal line complete and semicircular, area adjacent to postcoxal line smooth. Male genitalia (Figs. 4-6) as illustrated. Larva with dorsal surface covered with white waxy filaments.

The duration of life stages was shorter during summer (15.65 days in April) and longer during winter (26.52 days in December). The male to female ratio of beetle population was 1:0.95. Each female *S. coccivora* laid 84.7 eggs on an average when reared on grape mealybug, *Maconellicoccus hirsutus* Green. The percentage hatchability of the eggs was 89.86. The longevity of male and female beetles, respectively was 61.7 and 66.8 days when fed on grape mealybug. The adults were the potential feeders of mealybug eggs when compared with the grubs. Adult consumed 864.4 eggs, whereas larval consumption was 314.2 eggs during the life time. Preference for feeding was evident with *M. hirsutus* followed by *Ferrisia virgata* and *Plunococcus* spp. The egg, grub, prepupal and pupal stages occupy 4.13 – 4.20, 9.15 – 11.75, 1.25 – 1.40, 5.25 – 5.60 days respectively when the coccinellid is reared on different stages of *M. hirsutus*. The predatory grub consume 307.7 eggs or 62.2 nymphs or 6.55 adult females of *M. hirsutus* in confinement.

Mass production of *Scymnus coccivora*:

Material required:

Rearing cages, Red pumpkins, mealy bugs, motorised aspirator.

Procedure:

S. coccivora is multiplied on the ripe pumpkins infested by *Planococcus citris* as described under *P.citri*. The 15 – 20 day old mealy bugs are exposed to adult beetles. The beetles distribute their eggs singly or occasionally more than one egg is laid at a place. The eggs laid hatch in 4-5 days. The larval and pupal development is completed in 10 and 7 days respectively. The first adult emerges in 20 days time. Adult *S. coccivora* are harvested with a motorised aspirator within 4-7 weeks after initial oviposition. The beetles emerging daily are caged, allowed to mate and pass their preoviposition period. The beetles are then either field relased or used for continuation of culture.

Precaution:

All due precautions should be taken to avoid scarcity of food for the grubs to avoid cannibalism by grubs. All the pumpkins showing sign of rotting should be properly incinerated. Apart from the precautions required for handling pumpkins and the parasitoid, ringing the trunks leaving one foot away with a band of 5% diazinon granules before release of parasitoid should be adopted.

Maintenance of quality:

Sufficient food should be provided to the predators. Culture should be a pure one. Absence of live product contaminants, maintenance of purity and viability of the species are of great importance in order to maintain the quality. Breeding with field collected wild population after every third generation is advisable. Maintain strict hygienic conditions.

Transport:

S. coccivora is supplied as adults packed per certain number in plastic tubes with filter paper as carrier.

Field release:

Two releases of *Scymnus coccivora* @ 10 grubs per infested tree at monthly interval for suppressing the population of mealy bugs in fruit trees.

Dose:

Release predatory lady bird beetles *Scymnus coccivora* @ 250 adult beetles/ac, or 10 *S. coccivora* beetles per tree or 600-2500 per hectare are released.

Maintenance of history sheet:

The following information is furnished.

1. No. of adults released per cage.
2. Date of release.
3. Different developmental periods.
4. Expected date of adult emergence.
5. Collection of adults.
6. Problems encountered with the culture during production.

Biology of Host (*Planococcus citri*):

Eggs are deposited as white cottony masses called ovisacs giving the appearance of cotton spread. The glossy, light yellow eggs are oval and approximately 0.3 mm long. A female can lay from 300 to 600 eggs in her life period, which are deposited in groups of 5 to 20. Depending on the season, egg hatch may occur after 6 - 10 days or several weeks. First instar female and male nymphs

are called crawlers. The nymphs take 6 to 10 weeks to reach maturity. The nymphs are yellow, oval-shaped with red eyes, and covered with white waxy particles. Female nymphs have four instars. Males differ greatly; they have three instars and a pre-pupal stage. It is only the males that can produce a cottony-appearing cocoon and pupate. Adult size ranges in length from 3 mm (females) to 4.5 mm (males). The females are wingless, white to light brown in color, with brown legs and antennae. The body of adult females is coated with white wax and bears a characteristic faint gray stripe along their dorsal side. Females can live for up to 29 days depending on the host plant. Mealybugs remain motile throughout their life cycle, with the exception of the male pupa.

Host production:

Material required:

Wooden cage, white cloth or with nylon mesh, plastic ring, red pumpkin.

Procedure:

P.citri is produced on ripe pumpkins. The pumpkins are selected with ridges and groves with a small stalk which makes the handling easy. The pumpkins are thoroughly washed with tap water to remove dust particles. The pumpkins are then dipped in 0.1% (one gm/litre) solution of Benlate or Bavistin to kill all the fungal rot pathogens. The injured pumpkins are discarded or the wounds are plugged with hot paraffin wax.

Once the pumpkins get completely dried under shade. Each pumpkin is infested with *P.citri* crawlers (1^{st} instar mealy bugs) maintained in infestation room (in case the crawlers are not available, ovisacs of the mealy bug are placed over the pumpkin the crawlers emerging form ovisacs then settle on pumpkin). Each of the infested pumpkin is placed in 30 cm^3 wooden cage all sides of which are covered by white cloth or with nylon mesh. The cage has several variations but the one with slanting top and fixed with a slanting glass top and front sleeve has become quite popular. The pumpkin in the cage is kept from the front door opening on a round plastic ring. Such pumpkins are covered with mealy bugs in 15 days and the mealy bugs mature in another 12-15 days time.

Precaution:

Only the best quality of pumpkins should be selected for mealy bug rearing programme. Any pumpkin showing signs of rotting should be discarded immediately. Surface sterilize the pumpkin by dipping in a solution of 0.1% Benlate or Bavistin to kill all the fungal rot pathogens.

A sequence of pumpkin infestation cycle by mealy bugs has to be maintained to ensure availability of right stage of mealy bugs for exposing to the predators and parasitoids.

Maintenance of quality:

Culture should be a pure one, free from live product contaminants, parasitoids, diseases, etc.

Maintenance of history sheet:

The following information is furnished.

1. Date of infestation with mealybug.
2. Scientific name of the species.
3. Source of mealy bug.
4. Different developmental periods.
5. Problems encountered with the culture during production.

Reference:

Leppla, N.C, Bloem, K. A. and Luck, R.F.2002. Quality control for mass-reared arthropods. Proceedings of the Eighth and Ninth Workshops of the IOBC Working Group on Quality Control of Mass-Reared Arthropods.pp 171.

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http://ecoport.org/

http://entnemdept.ufl.edu/

http://www.nbaii.res.in

Mass production of Anthocorid bugs

Introduction:

Anthocorid bugs, particularly many species of the genus *Orius* (Heteroptera, Anthocoridae) are important beneficial insects for various agro systems feeding primarily upon thrips, aphids, leafhoppers, psyllids, spider mites, eggs and young larvae of several crop pests.

Cardiastethus pygmaeus Poppius, *C. affinis* Poppius and *C. exiguus* Poppius are key predators of coconut leaf caterpillars *Opisina arenosella* Walker and *Xylocoris (Arrostelus)* flavipes (Reuter) is associated with pest of stored grains/commodities.

Taxonomy, Identification and distribution of common species

Kingdom: Animalia
Class: Insecta
Order: Hemiptera
Family: Anthocoridae.

SN	species	Host	Crop	Distribution
1.	*Orius tantillus* (Motschulsky)	thrips, mites, *Helicoverpa armigera*, etc	Sunflower, cotton, chillies, marigold, etc.	Widely distributed in India.
2.	*Cardiastethus exiguous* Poppius	*Opisina arenosella*	coconut	Widely distributed in India.
3.	*Affinis* Poppius	*Opisina arenosella*	coconut	Widely distributed in India.
4.	*pygmaeus* Poppius	*Opisina arenosella*	coconut	Widely distributed in India.
5.	*Xylocoris flavipes* (Reuter)	*Ephestia kuehniella, Oryzaephilus* spp., *Tribolium castaneum*, etc.	Stored grains	Widely distributed in India.

Biology of Anthocorid bugs:

In most species the eggs hatch in 4-7 days and there are 5-6 nymphal instars, the duration for each instar being passed in 3-6 days. The adult males for 4-45 and female for 6-61 days. Each female is capable of producing about 150 eggs.

Mass production of Anthocorid bugs:

Material required:

Breeding cage, polystyrene wool, condensed milk, water.

Procedure:

Orius spp. Are reared in a specially designed cage which is made by converting a plastic playing card box into a breeding cage. Windows are cut on the top and bottom are replaced by plastic net to ensure proper aeration. On one lateral side a small window is cut which is replaced by a removable feeding pad. On the opposite side a similar window is cut and replaced by removable polystyrene wool. Once the cage are ready, twenty pairs of *Orius* spp. are introduced by removing one of the lateral opening. The food is provided (one part of water mixed with two parts of the condensed milk) on the lateral pad. The eggs are laid on the polystyrenes pad which is replaced daily with a fresh pad. The food also replaced daily and once in a week the entire assembly is changed and replaced by a fresh sterilized unit. A number of such units are set for rearing the required numbers of bugs. The cages are further stacked in a cage where a temperature of 25-26°C and relative humidity of 70-80% is maintained. The predatory bugs could also be reared on *Corcyra* eggs.

Precaution:

Among the precautions, the regular collection of bug eggs will avoid cannibalism and observance of strict hygienic conditions will prevent the attack of moulds.

Maintenance of quality:

Check the quality of the culture. If the fecundity is reduced, rear at least the stock culture on *Corcyra* eggs or *Spodoptera* eggs to bring back the original productivity. Sufficient food should be offered to the predators. Maintain strict hygienic condition. Breeding with field collected wild population of the same species after every third generation is advisable.

Transport:

Bugs are packed in plastic containers provided with sufficient Corcyra eggs and corrugated paper sheet.

Field release

Anthocorid bugs have gained prominence recently. Their conservation and application in cotton ecosystem will be big boost in protection technology for bollworms, aphids, thrips and mites on cotton and thrips , mites, lepidopterans particularly *Helicoverpa armigera* on sunflower. *Cardiastethus exiguus* can be utilized against coconut black-headed caterpillar, *Opisina arenosella* Walker, along with *C. affinis* Poppius, which it closely resembles.

Dose:

The dosage of release is being refined but coinciding the release of 50,000 bugs in 100 spots with initiation of flowering in cotton and 2 bugs per sunflower head will give effective suppression.

In case of *Cardiastethus exiguus* Poppius three to six releases of 50 adults or nymphs per palm at weekly intervals are recommended with the first release coinciding with egg laying by *O. arenosella.*

Maintenance of history sheet

The following information is furnished.

1. Date of egg laying.
2. Date of hatching.
3. Date of moulting of each instar.
4. Problems encountered with the basin during production
5. Biology of Host
6. 6. Host production: (add Photograph/ Sketch where ever required)

Reference:

Leppla, N.C, Bloem, K. A. and Luck, R.F.2002. Quality control for mass-reared arthropods. Proceedings of the Eighth and Ninth Workshops of the IOBC Working Group on Quality Control of Mass-Reared Arthropods.pp 171.

Manley, G. V. 1976. Immature Stages and Biology of *Orius tantillus* Hemiptera Heteroptera Anthocoridae Inhabiting Rice Fields In West Malaysia. Entomological News. 87(3&4):103-109.

National repository of natural enemies of crop pests and weeds. Final technical report (01-04-1997 to 31-03-2000). Project Directorate of Biological Control (Indian Council of Agricultural Research) Hebbal, Bellary road, Bangalore- 560 024.

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Thomas, J. M. G., Shirk P. D. and Shapiro, J. P. 2012. Mass rearing of a tropical minute pirate bug, *Orius pumilio* (Hemiptera: Anthocoridae). *Florida Entomologist*. **95**(1):202-204.

http://www.nbaii.res.in

Adult dorsal view Eggs

Orius (Dimorphella) tantillus (Motschulsky)

Cardiastethus exiguus Poppius

Cardiastethus pygmaeus

Mass production of *Reduviid* predators

Introduction:

Reduviids or assassin bugs are important natural enemies of *Helicoverpa armigera* and several other pests. On pigeonpea *Coranus* sp. *atricapillus* Distant and *C. spinicutis* Reuter, *Rhinocorus marginatus* (Fabricius), *R. fuscipes* Stal and several other species have been recorded feeding on *H. armigera*. Similarly these species have also been recorded on tobacco *Coranus* sp. *atricapillus* and *Harpector costalis* Stal are particularly abundant. It is quite interesting because on these two crops the diversity of natural enemies of *H. armigera* is not high as compared to other crops. The high longevity and prolonged predation is an advantage which could be harnessed by incorporating the reduviid bugs in biointensive IPM in relatively less preferred (by other natural enemies) crop ecosystems such as chickpea, pegeionpea and tobacco as well as in stable ecosystems such as orchards, forests etc.

Taxonomy, Identification and distribution of common species

Kingdom: Animalia
Class: Insecta
Order: Hemiptera
Family: Reduviidae

SN	species	Host	Crop	Distribution
1.	*Isyndus heros* (Fabricius)	Generalist predator.	Pulses	Widely distributed in India.
2.	*Endochus inornatus* Stal.	Generalist predator.	Pulses	Widely distributed in India.
3.	*Rhynocoris marginatus* Fab	Generalist predator. Host includes *H.armigera, S.litura, A.craccivora, etc*.	cotton, soybean, tomato and groundnut, pigeon pea	Widely distributed in India.
4.	*R. fuscipes*	Generalist predator.	Cotton, Okra, Ground nut, pigeon pea	Widely distributed in India.
5.	*R. longifrons*	Generalist predator.	Cotton, Okra, Pulses	Widely distributed in India.

Biology of *Reduviid* predators:

Most of the reduviids have fairly long life cycle; the egg, nymphal, adult male and female period varies from 8-11, 42-47, 85-125 and 85-137 days respectively. The female of different species lays eggs in batches of 10-28. The total fecundity varies from 42-205 eggs. Each individual species is capable of consuming 63 to 790 larvae of *H. armigera* or *Spodoptera litura* in its life time.

Mass production of *Reduviid* predators:

Material required:

Card sheets (10X3.5 cms), cellotape, jars (15 cm dia and 25 cm height), fourth and fifth instar *Cocryra* larvae, cotton, plastic vials (30 ml volume).

Procedure:

This technique was developed at IARI. In this technique, the head and thorax of *Corcyra cephalonica* larvae are firmly affixed on strips of card sheets (10X3.5 cms) using cellotape. This prevents the *C. cephalonica* larvae from webbing silk, cannibalism and spoiling the culture of the bugs. The larvae once fixed do not require any food, but the predators are attracted to strike on the wagging abdomen of fixed *C. cephalonica* larvae. The mass multiplication is done in jars (15 cm dia and 25 cm height) at room temperature (24-30^{o}C). Each card sheet can accommodate 70 *C. cephalonica* larvae and 25 pairs of reduviids are released per jar. Food is changed every alternate day. The egg batches laid by the female bugs in the laboratory were incubated in moist cotton swabs in small plastic vials (30 ml volume) to provide humidity.

Rediviids- *Rhynocoris* spp., *Acanthaspis* spp., *Sphedenolestes varibilis*, *Acanthaspis quineuespinosa* (Fabricius), *Brassivola hystrix* Distant, *Coranus* sp., *Endochus inornatus* Stal., *Endochus umbrinus*, *E. parvispinus* Distant, *Haematorrhopus linnaei* Stal, *H. nigroviolaceus* Reuter, *Irantha armipes* Stal, *Isyndus heros* (Fabricius) and few others could be multiplied by adopting this technique.

Endochus inornatus is the best predator followed by *Coranus* sp. Could be used against pests of pulses with a provision for natural or semi-permanent refuges for surviving the odd seasons.

Precaution:

Maintenance of sanitation has maximum relevance because of the long life cycle and adult longevity. In released fields wherever feasible, natural or semipermanent refuge should be made available for surviving the odd season.

Maintenance of quality:

Check the quality of the culture. Check for the fecundity of the species. Sufficient food should be offered to the predators. Maintain strict hygienic condition. Breeding with field collected wild population of the same species after every third generation is advisable.

Transport:

Packed in plastic containers provided with sufficient larval cards.

Field release:

R.fuscipes & R. longifrons have been successfully utilized in cotton in India. *R. marginatus* and *R. fuscipes* have been successfully utilized in groundnut in India. *Coranus* sp. could be released for the suppression of *H. armigera* infesting pulses. *Coranus* sp. And *Harpactor costalis* could be released in tobacco ecosystem for the suppression of *H. armigera* and other pests. About to hatch eggs of these predators pasted on cards could be uniformly distributed in endemic areas and nymphal instars may be released under the foliage with the help of small wet paintbrushes.

Dose:

20000 nymphal instars per hectare. 50000 eggs per hectare.

Maintenance of history sheet:

The following information is furnished.

- Date of preparation of larval cards.
- Date of hatching.
- Date of moulting of each instar.
- Number of generations.
- Problems encountered with the basin during production

Rhynocoris fuscipes

Rhynocoris longifrons

Rhynocoris marginatus

Isyndus heros (Fabricius)

Irantha armipes (Stål)

Acanthaspis sp.

Biology of Host (*Corcyra cephalonica*):

The eggs are oval and measure 0.5 x 0.3 mm. The white surface is sculptured and has a short nipple-like process at one end. The larvae are generally creamish – white except for the head capsule and the prothoracic tergite, which are brown. There are well-developed prolegs on abdominal segments 3-6 and 10. A fully matured larva measures 15 mm. The last-instar larva spins a closely woven, very tough, double-layered cocoon in which it develops into a dark-brown pupa. The anterior portion of the cocoon has a line of weakness through which the adult emerges. The adults are small. The hind-wings are pale-buff, and the fore-wings are mid-brown or greyish-brown with thin vague lines of darker brown colour along the wing veins. The males are smaller than the females.

Sexual activity usually begins shortly after adult emergence. There is a pre-oviposition period of about 2 days. Egg-laying mainly occurs during the night. The greatest numbers are laid on the second and third days after emergence, although oviposition may continue throughout life. Eggs take about 2-3 days to hatch. Optimum conditions for larval development of *C. cephalonica* are 30 –

32.5^{0}C and 70 per cent RH, at which, the period from egg hatch to adult emergence is only 26-27 days. There is considerable variation in the number of larval instars; however, males generally have 7 and females have 8. The last-instar larvae pupate within the food. The adults emerge through the anterior end of the cocoon, where there is a line of weakness. The sex ratio is 1:1. The adult moth is nocturnal and is most active at nightfall.

Host production:

Material required:

Absorbent cotton	Storage racks
Blotting paper	Streptomycin sulphate
Broken Pearl millet grain	Rubber band
Camel hair brush	Measuring cylinder
Enamel Tray	Oven
Honey	Home milling machine
Markin cloth	Sieves
Mosquito net	Formaldehyde 40%
Moth aspirator (collector)	Filter paper
Oviposition drums	Moth scale egg separator
Plastic basin	Face masks
Shoe brush	Storing drums
Soap	Ground nut kernel
Specimen tube	Sulphur (WP)
Yeast	Coarse weighing balance

Procedure:

Preparation of rearing basins

The basins (16" dia) used for *Corcyra* multiplication are thoroughly cleaned with 0.5% detergent wash and rinsing in tap water followed by wiping with dry, clean – used towel and shade drying. Whenever the trays are emptied after a cycle of rearing, they have to be cleaned preferably to 2 per cent formaldehyde and returned to storage until further use. On reuse the cleaning steps are repeated.

Preparation of bajra medium for *Corcyra*

a) The required quantities of bajra grains are coarsely milled and broken into 2-3 pieces in a milling machine. The broken grains are heat sterilized at 100^{0}C for 1 hour to eliminate the residual population of stored product insects *viz.*, *Rhizopertha dominica*, *Sitotroga cerealella*, *Tribolium castaneum* and fungal contaminants. Upon sterilization the grains are cooled under fan in a clean area. The grains are then transferred to plastic basins @ 2.5 kg/basin.
b) Groundnut kernel in required quantity is broken using a pounding machine or a mechanical blender (domestic mixer). Then 100 g of the broken kernel is transferred to each basin and the contents are hand mixed thoroughly.
c) Dry yeast (Bakers) and wettable sulfur is added @ 5g/ basin and the contents are mixed thoroughly. A spray of 10 ml of 0.01-0.05% streptomycin sulfate and mixing of the contents follows this. This medium is used for rearing *Corcyra* larvae.
d) The number of basins required for egg infestation is calculated and the medium is prepared accordingly.

Preparation of *Corcyra* eggs

The primary source of *Corcyra* eggs is reputed laboratories, commercial producers for bulk preparation. If it is intended to begin the production with nucleus colony, the adult moths can be collected from warehouses where the food materials are stored.

a) The eggs used for building up the colony of *Corcyra* have to be free from contaminants like the moth scales and broken limbs and not exposed to UV light.
b) The collections of overnight laid eggs are measured volumetrically to ascertain the number of trays that can be infested with eggs. A cc of eggs is known to contain approximately 16000 – 18000 eggs.

Infestation of medium with eggs

The overall production scheme involves initial infestation of the Pearl millet medium with *Corcyra* eggs in desired quantities. This is accomplished by sprinkling the freely flowing eggs on the surface of the medium in individual basins. Per basin 0.5 cc eggs of *Corcyra* is infested. The basins are then covered with clean *markin* cloth and held tightly with rubber fasteners. The basins are carefully transferred to the racks.

Handling the trays during larval development

The larvae that hatch out in 3-4 days begin to feed the fortified Bajra medium. At this stage, light webbings are noticed on the surface. As the larvae grow up they move down. During this period the larvae are allowed to grow undisturbed in the trays.

Handling of adults

The adults begin to emerge in 28-30 days after infestation of the eggs. The adults can be seen on the inner side of the *markin* cloth. They are either aspirated with mechanical moth collector or collected with specimen tubes. The whole operation

is carried out in a tent of mosquito net. This prevents the large-scale escape of the moths, which if uncontrolled can migrate to the storage area and spoil the grains stored by laying eggs. Workers involved in the collection of moths should wear face moths continuously to avoid inhalation of scales. The moths collected are transferred to the oviposition drum @ 1000 pairs per drum at a time. The oviposition drums of size 30 x 20 cm are made of galvanized iron. The drums rest on tripod frames with legs of height 5cm. The bottoms of the drums are provided with wire meshes that enable collection of eggs. The walls of the drums have two vents (ventilation holes) opposed to each other. The vents are again covered with wire mesh. The lids of the drums have handles besides slots for introducing the moths and adult feed. The oviposition drums filled in a day are maintained for four to seven successive days for egg collection after which are emptied and cleaned for next cycle of use.

The adults are provided feed containing honey solution. The adult feed is prepared by mixing 50 ml honey with 50 ml water and 5 capsules of vitamin E (Evion). The feed is stored in refrigerator and used as and when required. Piece of cotton wool tied with a thread is soaked in the solution and inserted into the drum through the slot at the top. From a basin, moths can be collected upto 90 days after which the number of moths emerging dwindles down and keeping the basins is not economical for the producer.

Handling of eggs

The moths lay the eggs in large numbers loosely. The scales and broken limbs are also found in larger quantities along with the eggs. They cause potential hazard to the workers after years of working in *Corcyra* laboratory. To minimize the risk of scales freely floating in the air, the oviposition drums are placed on sheets of filter paper in enamel trays which trap effectively the scales. Sets of several oviposition drums are kept in ventilated place near an exhaust fan to enable the workers comfort. Daily morning the oviposition drums are lifted up and the wire-mesh bottoms are cleaned gently with a shoe brush so that the eggs and remnants of scales and limbs settled on the mesh are collected along with those on the filter paper. The collections are cleaned by gently rolling the eggs on filter paper to another container. Then they are passed to sieves in series and finally clean eggs are collected. The eggs are quantified in measuring cylinders and used for building up the stocks and natural enemy production. About 100 pairs of adults produce 1.5 cc of eggs in 4 days laying period inside the oviposition drums. From each basin an average of 2500 moths are collected. Hence from each basin 18.00 – 20.00 cc of eggs can be obtained in 90 days.

Precaution:

Bacterial diseasemay affect the *Corcyra* culture. To control this, Streptomycin sulphate is added to the crushed graind at the rate of 0.2 gm/kg and mixed thoroughly. Occationally the mite *Pyemotes ventricosus* (Newport) may contaminate the culture and affect egg-laying and larval development. If mites are observed, thye racks, cages, boxes etc. should be disinfected with formalin and placed in the sun for six hours. Boxes containing developing larvae should be dusted with sulphur so that a thin layer of sulphur is present over the grains. If infestation is severe, it may be necessary to treat with the acaricide dicofol (Kelthane). For this, muslin sheets are dipped in a 0.05% solution of dicifol and air dried for a couple of hours. These sheets are spread over the grains in boxes. Mites coming in contact with the treated cloth are killed rapidly. *Bracon hebetor* Say must be kept away from infesting the culture of *C. cephalonica.*

Maintenance of quality: Accurate information is needed on the history of individual basins.

Maintenance of history sheet:

The following information is furnished.

1. Date of egg infestation
2. Date of preparation of feed
3. Source of egg
4. Expected date of adult emergence
5. Daily collection of moths
6. Problems encountered with the basin during production

Reference:

Leppla, N.C, Bloem, K. A. and Luck, R.F.2002. Quality control for mass-reared arthropods. Proceedings of the Eighth and Ninth Workshops of the IOBC Working Group on Quality Control of Mass-Reared Arthropods.pp 171.

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cephalonica Stainton larvae by larval card method. *Journal of Central European Agriculture*. **3** (2): 137-147.

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http://www.nbaii.res.in

Mass production of *Chrysopid predetors*

Introduction:

In India, 65 species of chrysopids belonging to 21 genera have been recorded from various crop ecosystems. Some species are distributed widely and are important natural enemies for aphids and other soft bodied insects. Amongst them, the green lacewing *Chrysoperla carnea* is the most common. *C. carnea* is now used extensively all over the country. It is being mass produced primarily on the eggs of rice grain moth, *Corcyra cephalonica* in India.

It is being mass released in the field for the control of aphids, white flies, mealy bugs and eggs and young larvae of lepidepteron pests. The *Chrysoperla* predetors may be used on cotton, groundnut, pulses, vegetables, ornamentals and several other crops. They also feed on the eggs and freshly hatched larvae of *Helicoverpa armigera* and such other caterpillar pests. They are capable of bringing down the population of the pest drastically. For mass production of *chrysoperla*, an efficient rearing technique is required.

Taxonomy, Identification and distribution of common species

Kingdom: Animalia
Class: Insecta
Order: Neuroptera
Family: Chrysopidae

SN	species	Host	Crop	Distribution
1.	*Chrysoperla carnea*	Generalist predator of soft bodied insects and lepidopterous pests.	Cotton, pulses, vegetables, Tobacco, oilseeds, fruit crops, plantation crops, etc.	Widely distributed in India
2.	*Mallada boninensis* (Okamoto)	Generalist predator of soft bodied insects and lepidopterous pests.	Cotton, pulses, vegetables, tobacco, oilseeds, fruit crops, plantation crops,etc.	Widely distributed in India
3.	*C. crassinervis* Esben-Peterson	Generalist predator of soft bodied insects and lepidopterous pests.	Cotton, pulses, vegetables, tobacco, oilseeds, fruit crops, plantation crops,etc.	Widely distributed in India

Biology of *Chrysoperla carnea*:

Chrysoperla are generally green in colour, varying in length from 1.0-1.3 cm. The pre-oviposition period lasts 3 to 7 days. Adults start laying eggs from 5th day onwards and peak egg-laying period is between 9 and 23 days after emergence. The male longevity is 30-35 days. Adult female lay eggs of 600-800 eggs/female on an average. The eggs are stalked and green in colour. The eggs are laid singly or in clusters. Egg stage lasts 3-4 days. The larva has 3 instars and after 8-10 days it will form cocoons. Adult emerges in 5-7 days from cocoons.

Mass production of *Chrysoperla carnea*:

Material required:

Facilities like rearing room (6 x 6 m), slotted angle iron racks, work tables, plastic louvers 60 x 22 cms with 2.5 cm cubical cells, acrylic sheets to cover the louvers, glass vials, adult oviposition cages (45 x 30 x 30 cms), plastic louvers, plastic containers, scissors and brushes, cotton wool, tissue

paper, sponge, fructose, protinex, honey, yeast, castor pollen etc. are required for the mass rearing of chrysopids.

Procedure:

In mass production, the adults are fed on various types of diets. The larvae are either reared in plastic tubes or empty injection vials or in groups in large containers or in individual cells. The most common method for the production of chrysopids is detailed below.

The adults are collected daily and transferred to pneumatic glass troughs or G.I. round troughs (30 cm x 12 cm). Before allowing the adults, the rearing troughs are wrapped inside with black sheet which act as egg receiving card. About 250 adults (60% females) are allowed into each trough and covered with white nylon or georgette cloth secured by rubber band. On the cloth outside three bits of foam sponge (2 sq.in) dripped in water is kept. Besides an artificial protein rich diet is provided in semisolid paste form in three spots on the cloth outside. This diet consists of one part of yeast, fructose, honey, Proteinex R and water in the ratio 1:1:1:1. The adults lay eggs on the black sheet. The adults are collected daily and allowed into fresh rearing troughs with fresh food. From the old troughs, the black paper sheets along with *Chrysopa* eggs are removed.

Storage and destalking of eggs

The brown paper sheet kept inside the adult rearing troughs contain large number of eggs each laid on a stalk or pedicel. As such the sheets are stored at 10^{o}C in B.O.D. incubator or refrigerator for about 21 days. When the eggs are required for culturing or for field release the egg sheets are kept at room temperature for a day and the eggs during this period turn brown and hatch on 3 days later. The first larvae are either taken for culture or for recycling or for field release.

Group rearing of grubs

It is done in GI round basins (28 cm dia) @ 250 larvae/basin, covered with *markin* cloth. The eggs of *Corcyra cephalonica* is given as feeding material for the larvae in the laboratory. For rearing 500 *Chrysopa* larvae the total quantity of *Corcyra* eggs required is 22 cc @ 5 cc/feeding for five feedings in alternate days. The *Chrysopa* larvae pupate into round white coloured silken cocoons in 10 days. The cocoons are collected with fine brush and transferred into 1 lit plastic containers with wire mesh window for emergence of adults. From the cocoons, pale green coloured adults with transparent lace like wings emerge in 9-10 days.

Individual rearing of grubs

In the first step of larval rearing, 120 three day old chrysopid eggs are mixed with 0.75 ml of *Corcyra* eggs (the embryo of *Corcyra* eggs are inactivated by keeping them at 2 feet distance from 15 watt ultraviolet tube light for 45 minutes) in a plastic container (27x18x6 cms). On hatching, the larvae start feeding. On 3rd day the larvae are transferred to 2.5 cm cubical cells of plastic louvers @ one per cell. Each louver can hold 192 larvae. *Corcyra* eggs are provided in all the cells of each louver by sprinkling through the modified salt shaker. Feeding is provided in two doses. First feeding of 1.5 ml *Corcyra* eggs for 100 larvae and second feeding of 2 ml for 100 larvae with a gap of 3-4 days is done. Total quantity of *Corcyra* eggs required for rearing 100 chrysopid larvae is 4.25 ml. The louvers are secured on one side by orgami or brown paper sheet and after transfer of larvae covered with acrylic sheet and clamped. Orgami or brown paper is used for facilitating pupation and clear visibility of eggs. The louvers are stacked in racks. One 2m x 1m x 45 cms angle iron rack can hold 100 louvers containing 19,200larvae.

Cocoons are collected after 24 hours of formation (when they get hardened) by removing orgami or paper from one side. The cocoons are placed in adult oviposition cages for emergence (Adults are sometimes allowed to emerge in louvers and released on glass window panes from where they are collected using suction pumps).

Precaution:

Chrysopid eggs should be packed in plastic jars with *Corcyra* eggs, paper strips should be provided to minimize contact and cannibalism between Chrysopid larvae in case larvae emerge during transit

Release should be made in early hours in the morning to allow larvae to settle on crop canopy.

Chrysopid larvae should be released in recommended numbers on crop, but on fruit crops, release should be made on infested plants/trees only.

Do not use pesticides in the field where predators are released. In case need arises use selective/safer pesticides and maintain a waiting period of atleast 10-15 days before making the release.

Do not release chrysopids in egg stage as they may get parasitized in the field by egg parasitoids or may be eaten by other predators.

Mallada boninensis and *M. astur* larvae carry trash on their body. Do not disturb this trash, the disturbance could injure the larvae.

Maintenance of quality:

Check the quality of the produce (each lot). If the fecundity is reduced, rear at least the stock culture on aphids to bring back the original productivity. Sufficient food should be provided to the predators. Absence of live product contaminants, maintenance of purity and viability of Chrysopids are of great importance in order to maintain the quality. Breeding with field collected wild population after every third generation is advisable.

Transport:

Chrysopid eggs should be packed in plastic jars with *Corcyra* eggs, paper strips should be provided to minimize contact and cannibalism between chrysopid larvae in case larvae emerge during transit.

Field release:

Normally, chrysopids are recommended for use against different crop pests @ 50,000 or 1,00,000 1st instar larvae/hectare, 4-6 larvae/plant or 10-20 larvae/fruit plant are released. Depending on the situation, two releases are recommended. They are released on the plants along with saw dust, or dropped from the corrugated paper strips.

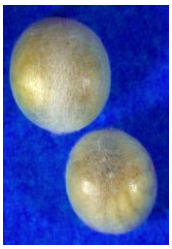
Dose:

Crop/Pest	**Species/ Numbers released**
Cotton Old world bollworm *Helicoverpa (=Heliothis) armigera* Spotted/spiny boll worms *Earias* spp. Pink bollworm *Pecticophora gossypiella* Whitefly *Bemista tabaci* Aphid *Aphis gossypii*	*Mallada boninensis or Chrysoperla carnea* @ 50,000/ha twice during the season with a gap of 15 days.
Tobacco Aphid *Myzus persicae* Tobacco caterpillar *Spodoptera litura* Whitefly *Bemisia tabaci*	*Chrysoperla carnea / Apertochrysa crassinervis* @ 50,000/ ha or 6 larvae per plant twice during the season with an interval of 15 days.
Sunflower Head borer *Helicoverpa armigera* Aphid *Aphis* sp.	*Chrysoperla carnea* @ 50,000/ ha 1st instar larvae twice during the season with an interval of 15 days.
Groundnut Aphid *Aphis craccivora*	*Chrysoperla carnea* @ 50,000/ ha 1st instar larvae twice during the season with an interval of 15 days
Fruit crops Aphids Other soft bodied insects	*Chrysoperla carnea or Mallada boninensis* @ 10-20 larvae per infested tree depending on the pest population.

Maintenance of history sheet:

The following information is furnished:

1. Date of egg collection.
2. Date of hatching.
3. Date of pupation.
4. Expected date of adult emergence.
5. Date of collection of adults.
6. Problems encountered with the culture during production.



Biology of Host (*Corcyra cephalonica*):

The eggs are oval and measure 0.5 x 0.3 mm. The white surface is sculptured and has a short nipple-like process at one end. The larvae are generally creamish – white except for the head capsule and the prothoracic tergite, which are brown. There are well-developed prolegs on abdominal segments 3-6 and 10. A fully matured larva measures 15 mm. The last-instar larva spins a closely woven, very tough, double-layered cocoon in which it develops into a dark-brown pupa. The anterior portion of the cocoon has a line of weakness through which the adult emerges. The adults are small. The hind-wings are pale-buff, and the fore-wings are mid-brown or greyish-brown with thin vague lines of darker brown colour along

the wing veins. The males are smaller than the females.

Sexual activity usually begins shortly after adult emergence. There is a pre-oviposition period of about 2 days. Egg-laying mainly occurs during the night. The greatest numbers are laid on the second and third days after emergence, although oviposition may continue throughout life. Eggs take about 2-3 days to hatch. Optimum conditions for larval development of *C. cephalonica* are 30 – 32.5^{0}C and 70 per cent RH, at which, the period from egg hatch to adult emergence is only 26-27 days. There is considerable variation in the number of larval instars; however, males generally have 7 and females have 8. The last-instar larvae pupate within the food. The adults emerge through the anterior end of the cocoon, where there is a line of weakness. The sex ratio is 1:1. The adult moth is nocturnal and is most active at nightfall.

Host production:

Material required:

Absorbent cotton	Storage racks
Blotting paper	Streptomycin sulphate
Broken Pearl millet grain	Rubber band
Camel hair brush	Measuring cylinder
Enamel Tray	Oven
Honey	Home milling machine
Markin cloth	Sieves
Mosquito net	Formaldehyde 40%
Moth aspirator (collector)	Filter paper
Oviposition drums	Moth scale egg separator
Plastic basin	Face masks
Shoe brush	Storing drums
Soap	Ground nut kernel
Specimen tube	Sulphur (WP)
Yeast	Coarse weighing balance

Procedure:

Preparation of rearing basins

The basins (16" dia) used for *Corcyra* multiplication are thoroughly cleaned with 0.5% detergent wash and rinsing in tap water followed by wiping with dry, clean – used towel and shade drying. Whenever the trays are emptied after a cycle of rearing, they have to be cleaned preferably to 2 per cent formaldehyde and returned to storage until further use. On reuse the cleaning steps are repeated.

Preparation of bajra medium for *Corcyra*

a) The required quantities of bajra grains are coarsely milled and broken into 2-3 pieces in a milling machine. The broken grains are heat sterilized at 100^{0}C for 1 hour to eliminate the residual population of stored product insects *viz.*, *Rhizopertha dominica*, *Sitotroga cerealella*, *Tribolium castaneum* and fungal contaminants. Upon sterilization the grains are cooled under fan in a clean area. The grains are then transferred to plastic basins @ 2.5 kg/basin.
b) Groundnut kernel in required quantity is broken using a pounding machine or a mechanical blender (domestic mixer). Then 100 g of the broken kernel is transferred to each basin and the contents are hand mixed thoroughly.
c) Dry yeast (Bakers) and wettable sulfur is added @ 5g/ basin and the contents are mixed thoroughly. A spray of 10 ml of 0.01-0.05% streptomycin sulfate and mixing of the contents follows this. This medium is used for rearing *Corcyra* larvae.
d) The number of basins required for egg infestation is calculated and the medium is prepared accordingly.

Preparation of *Corcyra* eggs

The primary source of *Corcyra* eggs is reputed laboratories, commercial producers for bulk preparation. If it is intended to begin the production with nucleus colony, the adult moths can be collected from warehouses where the food materials are stored.

- The eggs used for building up the colony of *Corcyra* have to be free from contaminants like the moth scales and broken limbs and not exposed to UV light.
- The collections of overnight laid eggs are measured volumetrically to ascertain the number of trays that can be infested with eggs. A cc of eggs is known to contain approximately 16000 – 18000 eggs.

Infestation of medium with eggs

The overall production scheme involves initial infestation of the Pearl millet medium with *Corcyra* eggs in desired quantities. This is accomplished by sprinkling the freely flowing eggs on the surface of the medium in individual basins. Per basin 0.5 cc eggs of *Corcyra* is infested. The basins are then covered with clean *markin* cloth and held tightly with rubber fasteners. The basins are carefully transferred to the racks.

Handling the trays during larval development

The larvae that hatch out in 3-4 days begin to feed the fortified Bajra medium. At this stage, light webbings are noticed on the surface. As the larvae grow up they move down. During this period the larvae are allowed to grow undisturbed in the trays.

Handling of adults

The adults begin to emerge in 28-30 days after infestation of the eggs. The adults can be seen on the inner side of the *markin* cloth. They are either aspirated with mechanical moth collector or collected with specimen tubes. The whole operation is carried out in a tent of mosquito net. This prevents the large-scale escape of the moths, which if uncontrolled can migrate to the storage area and spoil the grains stored by laying eggs. Workers involved in the collection of moths should wear face moths continuously to avoid inhalation of scales. The moths collected are transferred to the oviposition drum @ 1000 pairs per drum at a time. The oviposition drums of size 30 x 20 cm are made of galvanized iron. The drums rest on tripod frames with legs of height 5cm. The bottoms of the drums are provided with wire meshes that enable collection of eggs. The walls of the drums have two vents (ventilation holes) opposed to each other. The vents are again covered with wire mesh. The lids of the drums have handles besides slots for introducing the moths and adult feed. The oviposition drums filled in a day are maintained for four to seven successive days for egg collection after which are emptied and cleaned for next cycle of use.

The adults are provided feed containing honey solution. The adult feed is prepared by mixing 50 ml honey with 50 ml water and 5 capsules of vitamin E (Evion). The feed is stored in refrigerator and used as and when required. Piece of cotton wool tied with a thread is soaked in the solution and inserted into the drum through the slot at the top. From a basin, moths can be collected upto 90 days after which the number of moths emerging dwindles down and keeping the basins is not economical for the producer.

Handling of eggs

The moths lay the eggs in large numbers loosely. The scales and broken limbs are also found in larger quantities along with the eggs. They cause potential hazard to the workers after years of working in *Corcyra* laboratory. To minimize the risk of scales freely floating in the air, the oviposition drums are placed on sheets of filter paper in enamel trays which trap effectively the scales. Sets of several oviposition drums are kept in ventilated place near an exhaust fan to enable the workers comfort. Daily morning the oviposition drums are lifted up and the wire-mesh bottoms are cleaned gently with a shoe brush so that the eggs and remnants of scales and limbs settled on the mesh are collected along with those on the filter paper. The collections are cleaned by gently rolling the eggs on filter paper to another container. Then they are passed to sieves in series and finally clean eggs are collected. The eggs are quantified in measuring cylinders and used for building up the stocks and natural enemy production. About 100 pairs of adults produce 1.5 cc of eggs in 4 days laying period inside the oviposition drums. From each basin an average of 2500 moths are collected. Hence from each basin 18.00 – 20.00 cc of eggs can be obtained in 90 days.

Precaution:

Bacterial diseasemay affect the *Corcyra* culture. To control this, Streptomycin sulphate is added to the crushed graind at the rate of 0.2 gm/kg and mixed thoroughly. Occationally the mite *Pyemotes ventricosus* (Newport) may contaminate the culture and affect egg-laying and larval development. If mites are observed, thye racks, cages, boxes etc. should be disinfected with formalin and placed in the sun for six hours. Boxes containing developing larvae should be dusted with sulphur so that a thin layer of sulphur is present over the grains. If infestation is severe, it may be necessary to treat with the acaricide dicofol (Kelthane). For this, muslin sheets are dipped in a 0.05% solution of dicifol and air dried for a couple of hours. These sheets are spread over the grains in boxes. Mites coming in contact with the treated cloth are killed rapidly. *Bracon hebetor* Say must be kept away from infesting the culture of *C. cephalonica.*

Maintenance of quality: Accurate information is needed on the history of individual basins.

Maintenance of history sheet:

The following information is furnished.

1. Date of egg infestation
2. Date of preparation of feed
3. Source of egg
4. Expected date of adult emergence
5. Daily collection of moths
6. Problems encountered with the basin during production

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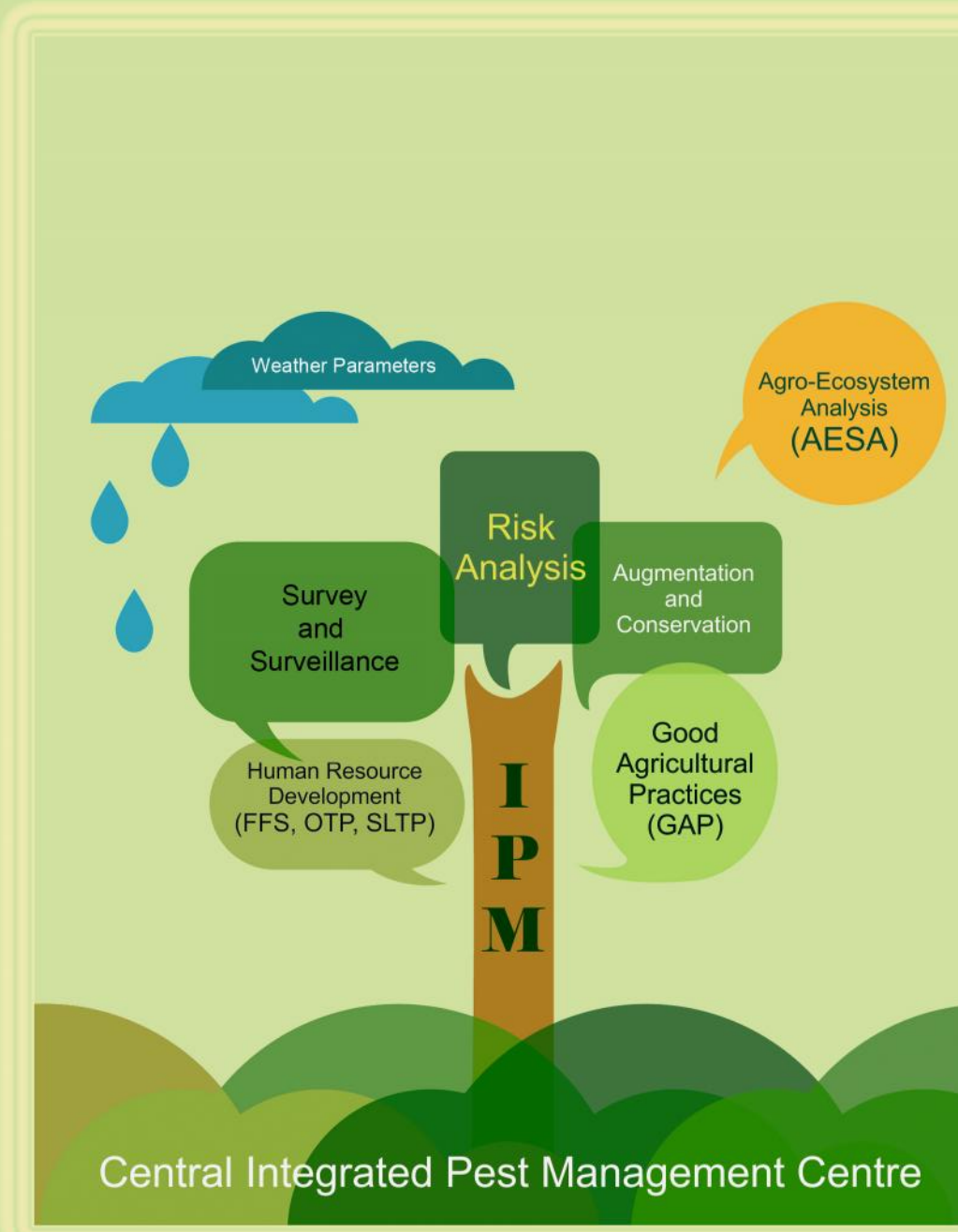

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