SATNET ASIA

Innovation network for food security and poverty reduction

SATNET Asia National Training Programmes on:

Bio-Intensive Pest Management of Economically Important Agriculture Crops

AND

Mass Scale Production of Bio-control Agents and Establishing a Bio-control Laboratory,

24-28 February, 2014, Thimphu, Bhutan

Workshop Report

UNITED NATIONS ESCAP Economic and Social Commission for Asia and the Pacific
CAPSA Centre for Alleviation of Poverty through Sustainable Agriculture
APCTT
FSC Food Security Center
AVRDC The World Vegetable Center
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The Network for Knowledge Transfer on Sustainable Agricultural Technologies and Improved Market Linkages in South and Southeast Asia (SATNET Asia) aims to support innovation by strengthening South–South dialogue and intraregional learning on sustainable agriculture technologies and trade facilitation. Funded by the European Union, SATNET facilitates knowledge transfer through the development of a portfolio of best practices on sustainable agriculture, trade facilitation and innovative knowledge sharing. Based on this documented knowledge, it delivers a range of capacity building programmes to network participants.

SATNET Asia is implemented by the Centre for Alleviation of Poverty through Sustainable Agriculture (CAPSA) in collaboration with the AVRDC – The World Vegetable Center, the Asian and Pacific Centre for Transfer of Technology (APCTT), the Food Security Centre of the University of Hohenheim and the Trade and Investment Division of UNESCAP.

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Executive Summary

Two SATNET National Training Programmes were organized by the Asian and Pacific Centre for Transfer of Technology (APCTT) of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) during 24-28 February 2014 in Thimphu, Bhutan in partnership with the Council of Renewable Natural Resources Research of Bhutan (CoRRB) of the Ministry of Agriculture and Forests (MoAF), Bhutan. The Training Programmes were on the subjects of: 1. Bio-Intensive Pest Management of Economically Important Agriculture Crops; and 2. Mass Scale Production of Biocontrol Agents and Establishing a Biocontrol Laboratory. This capacity building programme was organized as part of the Network for Knowledge Transfer on Sustainable Agricultural Technologies and Improved Market Linkages in South and Southeast Asia (SATNET) project funded by the European Union.

This second in-country SATNET Training programme for Bhutan was inaugurated by the Hon'ble Member of Parliament of Bhutan, H.E.Dasho Dophu Dukpa, and had the active participation of 27 participants representing various Departments and Divisions of CoRRB and MoAF from different provinces of Bhutan, including 5 women. The participants in the workshop were trained on the basic concepts and theory of integrated pest management and integrated disease management using biological control techniques, as well as on the rearing and mass production of biological control agents. The National Training Programmes aimed to train research scientists and extension workers to choose appropriate techniques and approaches on biological control of pests and diseases, and in pest management to maximize crop production while maintaining an ecological equilibrium. Further, the Training Programmes also aimed to strengthen the capacities of key stakeholders involved in plant protection and quarantine issues at the Bhutanese Ministry of Agriculture and Forests.

The training programme was designed in the form of interactive sessions. The resource persons trained the participants on various aspects of biological control techniques, with a specific emphasis on Integrated Pest Management (IPM), Integrated Disease Management (IDM), and the local production of biological control agents in Bhutan. Group discussions on specific case studies were facilitated by the resource persons, and the participants were encouraged to present success stories of biological pest control in Bhutan. The concluding session, chaired by APCTT, summarized the key learning outcomes of the training programme, the way forward for continuing capacity development on biological control in Bhutan, and opportunities to apply the tools, techniques and skills learned from this training programme to disseminate information on biological control nationally as well as establish a national biological control laboratory.

In the workshop feedback, participants highlighted the importance of this workshop for their future work, especially considering that Bhutan is on a road map to a fully organic agricultural system. Learning about biological control techniques and their use in the field, as well as about the mass rearing of beneficial biological control agents in a laboratory setting, was considered very important by the participants, since this increased their capacity to implement biological control on a nationwide scale using locally produced biological control agents. All participants will integrate IPM and IDM into their future work, and disseminate information and technical advice on IPM and IDM to farmers across Bhutan. However, many participants felt that the workshops might have been more productive if they had been held during a time of year when field visits were possible (i.e. during the growing season), so that they could have a better picture of IPM and IDM techniques in action.

1. Introduction

The Network for Knowledge Transfer on Sustainable Agricultural Technologies and Improved Market Linkages in South and Southeast Asia (SATNET) is working with institutions that share knowledge on sustainable agricultural technologies and improved market linkages in the region. SATNET facilitates knowledge transfer through the development of a portfolio of best practices on sustainable agriculture, trade facilitation and innovative knowledge sharing. Based on this documented knowledge, it delivers a range of capacity-building programmes to network participants. This will enable participants to transfer this knowledge to those who need it most – smallholder farmers and small-scale entrepreneurs.

Sustainable development requires knowledge and capacity in government agencies, businesses and local communities, to enable all stakeholders to participate in the decision making. Also, appropriate strategies to strengthen communities' abilities to identify with the desired change processes, and their capacities to implement the changes. Work package 4 (WP4) of SATNET Asia focuses on the knowledge transfer and capacity development aspects of the project, with a particular emphasis on South-South collaboration.

The Asian and Pacific Centre for Transfer of Technology (APCTT), a Regional Institution of the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) based in New Delhi, India is leading the implementation of SATNET Asia's capacity building programmes in South Asia. The two SATNET Asia National Training Programmes on Bio-Intensive Pest Management of Economically Important Agriculture Crops and the Mass Scale Production of Biocontrol Agents and Establishing a Biocontrol Laboratory, held from 24-28 February 2014, were the second National Training Programmes for key stakeholders in Bhutan. They were organized by APCTT in partnership with the Council for Renewable Natural Resources Research of Bhutan (CoRRB) of the Ministry of Agriculture and Forests (MoAF).

2. Programme structure

Methods used to train participants included group discussions, individual presentations, case studies, audio/video presentations, and practical exercises. A total of 27 participants, of which 5 were female that represented different offices of CoRRB and MoAF actively participated in this training. Below is the program summary of the National Training Programmes on Bio-Intensive Pest Management of Economically Important Agriculture Crops and the Mass Scale Production of Biocontrol Agents and Establishing a Biocontrol Laboratory.

2.1 National Training Programme on Bio-Intensive Pest Management of Economically Important Agriculture Crops

Day-1	Day-2
• Inaugural Session • Welcome Note • SATNET Introduction • Concept and Principles of Integrated Pest Management (IPM) • Relevance of Integrated Disease Management (IDM) • Importance of GAP in Pest Management • Role of Pest Surveillance in IPM • Principles of Scouting (Theory and Practical)	• Integrated Weed and Nutrient Management • Integrated Rodent Pest Management (IRPM) • Integrated Nematode Management • Introduction to Agro-Ecosystem Analysis (AESA) • Preparing the National Database of IPM: Application and Impact I • Preparing the National Database of IPM: Application and Impact II • Workshop Evaluation

2.2 National Training Programme on Mass Scale Production of Biocontrol Agents and Establishing a Biocontrol Laboratory: 26 – 28 February, 2014

Day-1	Day-2	Day-3
• Introduction of the Training Programme – Biocontrol Laboratory • Introduction to Biological Control: Principles, Concepts, Classification of Biocontrol Agents • Formulation and Mode of Action of Different Bio-pesticides • Isolation, Identification, and Mass Multiplication of Fungal Antagonists and Entomopathogenic Fungi (Theory) • On-farm Mass Production of Fungal Antagonists and Entomopathogenic Fungi	• Mass production of host insect Corcyra cephalonica, Parasitoid Trichogramma, Bracon and Predators (Theory + Practical) • Mass multiplication of mycopathogenic and entomopathogenic fungi– *Beauveria and Metarhizium (theory and practical)* • Role of entomopathogenic nematodes in insect pest management and mass multiplication of EPN (Theory) • Mass production of host insects and nuclear polyhedrosis virus	• Storage, Transport and Field release of Biocontrol agents and Biopesticides • Regulation of Bio-Control Agents • Conservation Biological Control Approaches for Pest Management • Summary and Way Forward • Workshop Evaluation

3. Key learning outcomes

3.1. National Training Programme on Bio-Intensive Pest Management of Economically Important Agriculture Crops

3.1.1. Concept, Principles and Relevance of Integrated Pest Management (IPM) and Integrated Disease Management (IDM)

On average, 18% of the crop yield in India is lost due to pests. To counter this, farmers use chemical pesticides. However, chemical pesticides are not always a solution to pest problems, but often they are the causes of problems themselves. In the past few decades excessive use of chemical pesticides in agricultural crops has resulted into multiple undesirable effects such as environmental damages, ecological imbalance, pesticide residues in food, vegetables, soil and ground water as well as adverse impacts on human and animal health.

Integrated Pest Management (IPM) is defined by FAO (1967) as a system that, in the context of associated environment and population dynamics of the pest species, utilizes all suitable techniques and methods in a compatible manner as possible and maintains pest populations at levels below those causing economic injury.

This session introduced the fundamentals of IPM and IDM by discussing the stages in crop protection that lead to IPM:

1. Subsistence phase: natural control, limited insecticide use
2. Exploitation phase: Applying more pesticides, growing HYV; higher yield and returns

3. Crisis phase: Due to increased pesticide use: problems of resurgence, resistance, secondary pest breakout = increase in production costs
4. Disaster phase: Overuse of pesticides = high residues in soil, little profit, collapse of control system
5. Integrated management phase: IPM integrates eco-friendly methods to optimize control measures

Stages 1 and 2 can be deemed the “era of optimism”, followed by the “era of doubt” (stages 3 and 4), and finally the “era of IPM” (stage 5).

Reasons why IPM strategies are necessary were discussed:
1. Development of resistance in insects against insecticides
2. Secondary pest outbreaks
3. Resurgence of target pests
4. Higher pesticide use = higher production costs and decreasing profit
5. Environmental contamination and damage due to chemical pesticide use
6. Chemical pesticides kill non-target flora and fauna, as well as beneficial populations
7. Human and animal health hazards due to chemical pesticide use (biomagnification)

The objectives of an integrated pest management strategy are:
1. Reduce pest population below economic injury level
2. Prevent pest population feeding, multiplication and dispersal
3. Use eco-friendly methods to maintain or enhance the quality of the agro-ecosystem
4. Apply control measures only when needed
5. Use all components and inputs in a sustainable manner

The requirements for a successful pest management programme are:
1. Correct identification of insect pests
2. Knowledge of life history of pests and natural enemies
3. Knowledge of effect of weather factors
4. Pest surveillance and pest forecasting
5. Finding out timing of control measures
6. Analysis of cost/benefit and benefit/risk of each control measure
7. Farmers’ awareness and participation

The IPM approach includes:
1. Host plant resistance measures: use of crop varieties with multiple pest resistance / tolerance.
2. Regulatory measures: eg. quarantine, certification of planting materials.
3. Cultural practices: eg. time of planting, crop rotation, field sanitation, integrated nutrient management, integrated nematode management, trap crops, etc.
4. Biological control: use of natural enemies, bio-control agents, bio-pesticides, etc.
5. Other physical measures: eg manual removal, radiation, solar heat treatment, pheromone traps, thermotherapy, etc.
6. Chemical control: judicious use of chemical pesticides, if absolutely necessary.

The IPM toolbox includes measures for:
1. Prevention: healthy crop production practices, regulatory measures, habitat management
2. Avoidance: eg timing of planting, location of field
3. Monitoring and management: to determine timing and appropriate actions
4. Intervention: direct control measures

In Integrated Disease Management (IDM), the development of diseases is seen as a close interaction among three factors: a susceptible host, a virulent pathogen, and a conducive environment. Therefore, diseases can be managed by eliminating interactions between these three factors. The goals of an IDM strategy are the simultaneous use of multiple disease management strategies, to suppress the disease incidence or severity, and to reduce the pathogen population.

The principles of IDM are:
1. Avoidance: eg. choice of geographical area, planting material, planting date

2. Exclusion: preventing disease from entering field through eg seed treatments, quarantine, hygienic farm measures
3. Eradication: destroying weeds that are reservoirs of disease or vectors of disease, biological control of plant pathogens, crop rotation, soil treatments, heat and chemical treatments
4. Protection: preventing infection by creating a chemical toxic barrier between the plant surfaces and pathogens
5. Resistant varieties: selection and hybridization for host disease resistance
6. Therapy: reducing severity of disease by using chemicals: chemotherapy, tree surgery, heat therapy

Successful IDM includes:

- An emphasis on prevention rather than cure
- Early detection: daily (or at least twice-weekly) monitoring of crops by walkthrough
- Farmers' detailed record-keeping of progress and problems of crop: cultural, environmental, insect and disease data
- Weather monitoring to anticipate potential disease problems

3.1.2. Practices related to IPM and IDM

The holistic IPM and IDM approach involves several different kinds of practices. Therefore, further sessions focused in on topics such as integrated weed and nutrient management, Integrated Rodent Pest Management (IRPM), and integrated nematode management. Additionally, the importance of using good agricultural practices for more efficient pest management was stressed.

These practices, related to IPM and IDM, all focus on the systems approach, whereby whole land use planning is done to minimize the invasion of weeds, pests and diseases and effectively maximize the use of nutrients and other biological inputs, to produce a healthy, high-yield crop.

3.1.3. Agro-Ecosystem Analysis (AESA)

The concepts of Agro-Ecosystem Analysis (AESA) were introduced. AESA helps farmers to critically assess the situation of their fields, with the goal of aiding the farmer in taking appropriate decisions on management practices.

When conducting AESA, a field is analyzed focusing on its plant health, soil conditions, pests, beneficial organisms, the influence of climatic factors and their interrelationships, as they relate to healthy crop production. The basic components of AESA are:

1. Plant health at different stages
2. Built-in compensation abilities of the plants
3. Pest and beneficial population dynamics
4. Soil conditions
5. Climatic factors
6. Using farmers' past experiences

Record-keeping is an integral part of AESA.

3.1.4. Role of Pest Surveillance in IPM & Principles of Scouting (Theory and Practical)

Pest surveillance and crop scouting should be part of an IPM strategy. Whereas pest surveillance should be done routinely by the farmers as part of an early warning system for psts and diseases, crop scouting is a precise assessment of pest pressure (mainly for insect pests) and crop performance.

Crop scouting is done to understand the economic risk from pest infestations and disease, as well as to identify the potential effectiveness of pest and disease control interventions. The basics of crop scouting are twofold:

- Accurate estimations of crop plant health, stand, growth stage and populations of any pests present;
- Pest identification and/or diagnosis of the cause of crop injury.

Participants learned the steps of crop scouting:

1. How to collect background information about the field (the field history)
2. What equipment is necessary for crop scouting
3. How to map fields using a soil map
4. Using scouting patterns across the field to check individual plants
5. Record information
6. Assess: incidence and severity

3.1.5 Preparing the National Database of IPM: Application and Impact I & II

The steps to an effective IPM were presented:

- Understand site management objectives
- Establish short- and long-term priorities
- Identify and monitor pest species, their biology, and conditions conducive to them
- Understand the physical and biological factors that affect the number and distribution of pests and their natural enemies
- Conserve natural enemies
- Establish ‘action thresholds’ at which point an approved management strategy will be implemented to reduce the pest population
- Document and maintain records

At the national level, an IPM includes:

- Cultural practices
- Scouting and ID of pests and beneficials
- Conservation of beneficials
- Augmentation of beneficials
- Reduced-risk insecticides
- Resistance management

Steps for planning a national IPM are:

1. State goals and objectives
2. Map priority crops and areas
3. Draft guidelines and designate authorities; include legal and regulatory mechanisms
4. Set up laboratory for producing bio-control agents
5. Encourage cultural control
6. Keep and review detailed pest management activity records: create national electronic pest management database system

Advantages of a national database:

- Precision and timeliness of interventions

- Assess the relationship between environmental conditions and the occurrence of pest and disease outbreaks
- Forecasting and simulating models
- Provide data to evaluate the roles of predators and parasitoids as pest population regulators
- Quarantine pests and pests analysis

3.2. National Training Programme on Mass Scale Production of Biocontrol Agents and Establishing a Biocontrol Laboratory

3.2.1. Introduction to Biological Control: Principles, Concepts, Classification of Biocontrol Agents

Biological control is the deliberate use of one organism (a 'natural enemy') to regulate the population size of a pest organism. Integrated pest management practices and in particular, biological control approaches targeting control of insect pests and diseases of agricultural crops are a very promising alternative to synthetic pesticides. The biological control approaches are environment-friendly, effective against a broad range of insect pests and are easy to adopt. In the past 120 years, 2,700 species have been introduced as natural enemies over 7,000 times in 196 countries across the globe.

Natural enemies used as biocontrol agents are classified as follows. A broad array of examples was given, and the life cycle and mode of action of an entomopathogenic nematode was presented.

- Entomophages:
    - Parasitoids:
        - Egg parasitoids
        - Larval parasitoids
        - Pupal parasitoids
        - Intermediary parasitoids
    - Parasites:
        - Monophagous predators
        - Oligophagous predators
        - Polyphagous predators
- Entomopathogens
    - Bacteria
    - Viruses
    - Fungi
    - Protozoa
    - Nematodes

Classical biocontrol involves the introduction of an imported species, to permanently colonize the pest-infected area. Other biocontrol mechanisms include augmentation, which is the periodical introduction of natural enemies to achieve pest control. Natural enemies used in augmentation do not establish and need to be introduced each time pest populations reach the threshold level. Natural enemy populations are augmented through either:

- innoculation (when natural enemies reproduce and live longer, smaller amounts of biocontrol agents are released) or
- inundation (when natural enemies don't reproduce, inundation is the mass release of biocontrol agents).

When deciding on which natural enemy to augment, following issues are important. The natural enemy should:

- be adapted to focus area
- be easy to culture

- have a preference for the pest species
- have a higher reproductive rate than the pest species
- have a good response to pest densities
- not attack other natural enemies

The life cycle, mode of action and field dosage rates for *Trichogramma sp.* were given as an example.

Conservation in biocontrol is a long-term solution to pest problems. The process of conservation involves manipulation of the habitat to favour natural enemies, either by removing or mitigating adverse conditions, or by inducing the favourable factors.

The application of chemical pesticides does not just reduce pest populations, but destroys natural enemy populations as well. Suggestions for safer pesticide use were given:

- Pesticide selectivity: selection of safer pesticides, eg. Spinosad, a microbial insecticide derived from a species of Actinomycetes bacteria that lives in soil
- Temporal separation of natural enemies and pesticides: application of pesticides when key natural enemies are absent, or present in a more tolerant stage.
- Spatial separation of natural enemies and pesticides: spot treatment; treatment of alternate rows.
- Improved knowledge of non-target pests and natural enemies
- Use of botanical and microbial pesticides

3.2.2. Formulation and Mode of Action of Different Bio-pesticides

Biopesticides are mass produced biologically based agents used for the control of plant pests. They can be living organisms or naturally occurring substances (biochemical) such as plant extracts (eg many insecticides are produced from the seeds of the Neem tree) and semiochemicals (pheromones and allelochemicals). Mating disruption pheromones are heavily used in western fruit and nut production.

Biopesticides have a key and specific role to play in crop protection as part of IPM; as biochemical substances, they should be regulated. Biopesticides have following characteristics:

- Often very specific
- Compatible with other control agents
- Little or no residue
- Inexpensive to develop
- Natural enemies used in ecologically-based IPM
- Lower potency than synthetic pesticides

Biocontrol has been shown successful to control: rusts, powdery mildews, and diseases caused by *Alternaria, Epicoccum, Sclerotinia, Septoria, Drechslera, Venturia, Plasmopara, Erwinia,* and *Pseudomonas*. Good soil biocontrol systems have been reported for species of *Fusarium, Sclerotinia, Phythium*, and *Rhizoctonia*.

Biocontrol agents may have several modes of action; therefore, it is important to know the proportion and timing of each mode of action that may occur. Mechanisms of biocontrol of plant diseases are:

- Induced resistance: a plant response to challenge by microorganisms or abiotic agents; can be localized (when resistance occurs only in the area immediately adjacent to the induced factor; this occurs in many plant species) or systemic (when resistance occurs subsequently at other sites in the plant; this is limited to some plant species).

- Hypovirulance: reduced virulence found in some strains of pathogens, with naturally occurring hypovirulent strains able to reduce the effect of virulent ones.
- Competition: using the competition that occurs between microorganisms for resources such as space and nutrients as a form of biocontrol
- Antibiosis: the production of antibiotics by bacteria and fungi
- Mycoparasitism: one fungus parasitizes another (eg. *Trichoderma*). Biotrophic mycoparasites live within or from the host fungus; necrotrophic mycoparasites kill the host cells.
- Biocontrol of airborne pathogens: to control diseases on aerial surfaces of plants, many naturally occurring microorganisms have been used (eg bacteria: *P. fluorescens, P. cepacia*; fungi: *Trichoderma, Ampelomyces*; yeasts *Tilletiopsis, Sporobolomyces*). The mechanisms of action include competition for sites and nutrients, and antibiosis.
- Biocontrol of soil borne pathogens: Biological control agents colonize the rhizosphere, the site requiring protection, without leaving toxic residues (as opposed to chemicals). Perhaps the most successful biocontrol agent of a soilborne pathogen is *Agrobacterium radiobacter* strain K84, used against crown gall disease caused by *A. tumefaciens.*

The biocontrol activity offered by *Trichoderma* was presented in detail. *Trichoderma* is a valuable biocontrol agents due to its ability to serve as antagonist and its role in promoting plant growth, inducing plant defences, and soil colonization.

3.2.3. Storage, Transport and Field release of Biocontrol agents and Biopesticides; Isolation, Identification, and Mass Multiplication of Fungal Antagonists and Entomopathogenic Fungi (Theory)

Success of biological control depends on:

- Selection of suitable strain
- Production of quality bioagents and formulation
- Storage and transport
- Field release

Major problems concerning the implementation of a nationwide biocontrol system involve the distance between rearing units and fields, which means it takes a long time to transport the biocontrol agents between the locations. Additionally, there may be a lack or non-availability of trained persons. These situations jeopardize the survival of the bioncontrol agents, and the programming of parasitoid emergence.

Because the basal metabolic rate of cold blooded animals reduces at low temperature, insects are best stored between 5 - 10°C. *Trichogramma*, for example, can be best stored at the pupal stage (i.e. when the eggs turn black) at 10º C, for up to 49 days (however, best is stored for not longer than 2-3 weeks). The mass production, method of transport and field release of *Trichogramma, Chrysoperla carnea, Cotesia flavipes & Chelonus blackburni,* entomopathogenic fungi, nuclear polyhedrosis viruses, entomophilic nematodes, and the parasitoid *Epiricania melanoleuca* was detailed, as well as factors impacting their field release timing.

To overcome transport issues, participants learned details about the on-farm mass production of fungal antagonists and entomopathogenic fungi, the mass production of the host insect Corcyra cephalonica, the parasitoids Trichogramma and Bracon, and predators, and the role of entomopathogenic nematodes (EPN) in insect pest management and mass multiplication of EPN.

3.2.4. Regulation of Bio-Control Agents

Important issues to consider when regulating biocontrol agents are:

- Regulation should be proportionate

- Risk and not hazard based
- Not a financial deterrent
- Predictable in requirements
- Predictable in duration
- Consistent but flexible
- Incorporate conditional requirements

International context:

- WTO Agreement on the Application of Sanitary and Phytosanitary Measures
- International Plant Protection Convention (IPCC)

Standards for pest risk analysis are as follows. The objectives of the standard are to facilitate the safe export, shipment, import and release of biological control agents and other beneficial organisms.

- ISPM No. 2: Framework for pest risk analysis (1995)
- ISPM No. 11: Pest risk analysis for quarantine pests (2004)
- ISPM No. 3: Guidelines for the export, shipment, and release of biological control agents and other beneficial organisms (2005)
- ISPM No. 21: Pest risk analysis for regulated non-quarantine pests (2004)
- ISPM 8: definition of pest record and criteria for evaluating a record
- Information sources and how criteria can be used to evaluate the records they contain
- Importance of reference collections
- Information management system
- Local databases
- Sharing information among databases
- National Plant Pest Database
- Global linking of databases

Responsibilities of countries importing and exporting biocontrol agents were detailed, along with the creation of a national standard for biocontrol, with the view of creating a national biocontrol system in Bhutan.

3.2.5. Conservation Biological Control Approaches for Pest Management

Ecological approaches in conservation address the root causes of parasitoid failure: disturbances and the lack of population persistence. Disturbances can be abiotic (eg landslides, floods, fires), or biotic. Biotic disturbances can be at the level of the crop, the farm, or the landscape.

Tactics of conservation include:

- Altering pesticide use: in IPM, the role of natural enemies is large, and the role of pesticides is small.
- Habitat manipulation:
    - Ecological compensation areas
    - Intercropping
    - Push-pull technology
    - Providing artificial structures for beneficial populations

4. Way forward

Feedback from the workshop showed that participants felt that they strongly benefitted from the workshop. Participants highlighted the usefulness of learning IPM, IDM, and biocontrol techniques, especially in Bhutan, and the benefits of implementing IPM and biocontrol in their respective areas in Bhutan. All participants will be integrating IPM concepts and techniques learned in the workshop in their work, as well as further spreading knowledge to extension workers and agencies in Bhutan. Going forward, participants want to increase their capacities to implement biological control techniques at the farm, landscape, ad nationwide level by further trainings on the subject.

On a national level, the Government of Bhutan is formulating a national biocontrol strategy as part of the transition to a nation-wide organic production system. Biocontrol agents will be produced in-country in a national biocontrol laboratory at the National Plant Protection Center (NPPC). The NPCC is part of the Department of Agriculture, which is under the Ministry of Agriculture and Forests. The research scientists who attended the SATNET National Training Programmes will facilitate the laboratory at the NPCC, while the attending extension agents will recommend and implement biocontrol measures against pests and diseases of the major agricultural crops in disparate areas nationwide. A March 9, 2014 article in The Bhutan Times highlighted the importance of SATNET's National Training Programmes on Biocontrol (see annex 4), and further disseminated information on the National Training Programmes and biocontrol in Bhutanese agriculture to a wider public.

Annex 1: Workshop Evaluations

The evaluation of the workshop was conducted based on two different approaches including (i) general feedback and (ii) Knowledge, Attitude and Practice (KAP) Survey. The criteria of evaluation were completed on the scale of excellent, good, fair and poor. Further, the general feedback part was divided into two segments (content and process). Hence, this part was evaluated based on the delivery of technical sessions by the resource persons. The second part of the evaluation was prepared using the perception based approach known as Knowledge, Attitude and Practice. This segment of the evaluation mainly discusses individual knowledge gained from the workshop as well as the implementation of specific knowledge in the participants' own areas of research.

On the final day of each workshop, evaluation forms were received from the participants to assess the workshops according to their usefulness in dissemination of knowledge, quality and innovation of biological control techniques. Overall the workshop was rated as good by more than 75% of the participants, followed by the excellent category.

Participants were given evaluation forms to rate the usefulness of the workshop content and quality of processes on the scale of "excellent to poor". Averaging both workshops, statistics in the table show that the workshops were rated as good, since around 80% of the responses were observed under the categories "good" and "excellent" in terms of the workshop content and processes. 46% of the participants rated the processes as good while over 40% rated them as excellent.

1. National Training Programme on Bio-Intensive Pest Management of Economically Important Agriculture Crops (24 – 25 February 2014)

Usefulness of the content and quality of processes and logistics

Topics
In addition, topics 8 & 6 were rated 86% and 81% respectively in the "good" category because of the innovative knowledge these topics offered in terms of choices of sustainable agricultural technologies and their economic benefits. The other topics were rated either excellent or good by the participants because of their valuable addition to the participants' existing knowledge base.

Expectations

About 52% of the participants indicated that this workshop met their overall expectations on a large scale, while 33% of the participants felt that the workshop met its objectives beyond their expectations. However, 15% of participants indicated that the workshop met just their minimum requirements.

Table 1: Participant responses from the National Training Programme on Bio-Intensive Pest Management of Economically Important Agriculture Crops (24 – 25 February 2014) (25 participants)

	Topics	Excellent	Good	Fair	Poor
Content	Topic 1: Concepts and principles of Integrated Pest Management	68	32		
	Topic 2: Relevance of Integrated Disease Management	60	40		
	Topic 3: Importance of Good Agricultural Practices in Pest Management	60	40		
	Topic 4: Role of Pest Surveillance in IPM	52	48		
	Topic 5: Principles of Scouting (Theory and Practical)	40	56	4	
	Topic 6*: Integrated Weed and Nutrient Management	48	44	8	
	Topic 7: Integrated Rodent Pest Management	44	52	4	
	Topic 8*: Integrated Nematode Management	52	40	4	
	Topic 9*: Introduction to Agro-Eco System Analysis (AESA)	40	48	4	
	Topic 10: Preparing the National Database of IPM: Application and Impact-I	36	60	4	
	Topic 11: Preparing the National Database of IPM : Application and Impact-II	36	60	4	
Process	Agenda and flow*	32	60		
	Facilitation, feedback and discussion	48	44	8	

*: not all participants rated this part of the workshop, so the totals do not add up to 100%

2. National Training Programme on Mass Scale Production of Biocontrol Agents and Establishing a Biocontrol Laboratory (26 – 28 February 2014)

Usefulness of the content and quality of processes and logistics

Topics 1 (Concepts and Principles of IPM), 2 (Relevance of IDM), and 3 (Importance of Good Agricultural Practices in Pest Management) were rated the highest in terms of the “excellent” category.

Expectations

About 70% of the participants indicated that the workshop met their overall expectations on a large scale, while 25% of the participants felt that the workshop met its objectives beyond their expectations. However, 4% of the participants thought the workshop was just fair in quality.

Table 2: Participant responses from the National Training Programme on Mass Scale Production of Biocontrol Agents and Establishing a Biocontrol Laboratory (26 – 28 February 2014) (27 participants)

	Topics	Excellent	Good	Fair	Poor
Content	Topic 1: Introduction to Biological Control, Principles and concepts, classification of bio-control agents	67	33		
	Topic 2: Formulation and mode of action of different bio-pesticides	52	41	7	
	Topic 3: Isolation, identification and mass multiplication of fungal antagonists and entomopathogenic fungi (Theory)	56	44		
	Topic 4: On-farm mass production of fungal antagonists and entomopathogenic fungi	74	26		
	Topic 5: Mass production of host insect Corcyra cephalonica, Parasitoid Trichogramma, Bracon and Predators (Theory + Practical)	67	33		
	Topic 6: Mass multiplication of mycopathogenic and entomopathogenic fungi– Beauveria and Metarhizium (theory and practical)	63	37		
	Topic 7: Role of entomopathogenic nematodes in insect pest management and mass multiplication of EPN (Theory)	63	33	4	
	Topic 8: Mass production of host insects and nuclear polyhedrosis virus	74	22	4	
	Topic 9*: Storage, transport and field release of Biopesticides and Biocontrol Agents	56	37	4	
	Topic 10: Regulation of Biocontrol Agents	41	52	7	
	Topic 11: Conservation Biological Control Approaches for Pest Management	41	52	7	
Process	Agenda and flow*	41	44		
	Facilitation, feedback and discussion*	44	37		

*: not all participants rated this part of the workshop, so the totals do not add up to 100%

Aspects to be improved in the future

Participants felt that the inclusion of more case studies, specifically the different timing of the workshops to allow field visits during the growing season, to consolidate the learning from the sessions would have been very useful. A brief summary of key suggestions from the participants is provided below:

Content

- Provide more information on the Bhutan-oriented application of biological control techniques, especially the local infrastructure for timely access to mass quantities of appropriate biological control agents
- Include some sessions on
- More case studies of IPM and IDM at the farm level in Bhutan
- Emphasis on mathematical calculations should be less and usage of software should be more

- Several participants indicated that the training programme on bio control should also focus on different aspects such as Integrated Pest Management and climate change

Process

- Presentations should be more simplistic and use less jargon
- More comprehensive discussions on case studies
- More group discussions on IPM

Logistics

- Presentation files should be distributed well in advance to the participants
- The duration of the workshop on IPM and biocontrol should be more than 3 days for facilitating group discussions and collective learning.

Way Forward

- Most of the participants indicated that they will apply this knowledge in their research work and will also provide assistance to other organizations in evaluating the economic feasibility of agricultural technologies and/or projects.
- Some participants said that they would also disseminate this training to interested colleagues in their respective offices and divisions of MoAF.

Annex 2: Agenda of the National Training Programmes

2.1. SATNET Training Programme on Bio–intensive Pest Management in Economically Important Agricultural Crops, 24-25 February 2014, Thimphu, Bhutan

Day 1: 24 February 2014

Time	Programme	Speakers
	Inaugural Session	
09:00-09:10	Welcome Address and Introduction of NPPC and MoAF	Dr.Yeshey Dema NPPC
09:10-09:20	Opening Address	Dr. Krishnan Srinivasaraghavan, APCTT-ESCAP
09:20-09:40	An overview of SATNET Asia project	Mr. Suraj Pandey APCTT-ESCAP
9.40-10.40	Concepts and principles of Integrated Pest Management	Dr.P. JeyaKumar, NIPHM
10.40-11.00	**Tea/Coffee Break**	
11.00-12.00	Relevance of Integrated Disease Management	Dr.Kavya Dashora CABI
12.00-13.00	Importance of Good Agricultural Practices in Pest Management	Dr.P. JeyaKumar, NIPHM
13.00-14.00	**Lunch Break**	
14.00-15.00	Role of Pest Surveillance in IPM	Dr.P.JeyaKumar, NIPHM
15.00-15.15	**Tea/Coffee Break**	
15.15-16.15	Principles of Scouting (Theory and Practical)	Dr.Kavya Dashora CABI

Day 2: 25 February 2014

Time	Programme	Speakers
09.00-10.00	Integrated Weed and Nutrient Management	Dr.Kavya Dashora CABI
10.00-11.00	Integrated Rodent Pest Management (IRPM)	Dr.P.JeyaKumar, NIPHM
11.00-11.15	**Tea/Coffee Break**	
11.15-12.00	Integrated Nematode Management	Dr.P.JeyaKumar, NIPHM

12.00-13.00	Introduction to Agro-Eco System Analysis (AESA)	Dr.P.JeyaKumar, NIPHM
13.00-14.00	**Lunch Break**	
14.00-15.00	Preparing the National Database of IPM : Application and impact-I	Dr.Kavya Dashora CABI
15.00-15.15	**Tea/Coffee Break**	
15.00-16.00	Preparing the National Database of IPM : Application and impact-II	Dr.Kavya Dashora CABI
16.00-16.15	**Workshop Evaluation and Feedback**	Mr. Suraj Pandey APCTT-ESCAP
16.15-16.30	**Concluding Remarks**	NPPC, MoAF

2.2. SATNET Asia National Training Programme on "Mass Scale production of Bio-control Agents and Establishing a Bio-control Laboratory, 26-28 February 2014, Thimphu, Bhutan

Day 1: 26 February 2014

Time	Programme	Speakers
09.00-9.10	**Introduction of the Training Programme-Bio-control Lab**	Mr.Kiran Mahat NPPC
09:10-10.30	Introduction to Biological Control, Principles and concepts, classification of bio-control agents	Dr.P.JeyaKumar, NIPHM
10.30-11.00	**Tea/Coffee Break**	
11.00-12.00	Formulation and mode of action of different bio-pesticides	Dr.Kavya Dashora CABI
12.00-13.00	Isolation, identification and mass multiplication of fungal antagonists and entomopathogenic fungi (Theory)	Dr.P.JeyaKumar, NIPHM
13.00-14.00	**Lunch Break**	
14.00-16.00	On-farm mass production of fungal antagonists and entomopathogenic fungi	Dr.P.Jeya Kumar, NIPHM & Dr.Kavya Dashora, CABI

Day 2: 27 February 2014

Time	Programme	Speakers
09.00-11.00	Mass production of host insect Corcyra cephalonica, Parasitoid Trichogramma, Bracon and Predators (Theory + Practical)	Dr. P. Jeya Kumar, NIPHM
11.00-11.15	**Tea / coffee break**	
11.15-13.00	Mass multiplication of mycopathogenic and entomopathogenic fungi– *Beauveria and Metarhizium* (theory and practical)	Dr. Kavya Dashora CABI
13.00-14.00	**Lunch break**	
14.00-15.00	Role of entomopathogenic nematodes in insect pest management and mass multiplication of EPN (Theory)	Dr. P. Jeya Kumar, NIPHM
15.00-15.15	**Tea / coffee break**	
15.00-16.00	Mass production of host insects and nuclear polyhedrosis virus	Dr. P. Jeya Kumar, NIPHM

Day 3: 28 February 2014

Time	Programme	Speakers
9.00-10.00	Storage, Transport and Field Release of Biocontrol agents and Biopesticides	Dr. P.Jeyakumar NIPHM
10.00-11:00	Regulation of Bio-Control Agents	Dr.Kavya Dashora CABI
11:00-11:30	**Tea/Coffee break**	
11.30-13.00	Conservation Biological Control Approaches for Pest Management	Dr.P.JeyaKumar, NIPHM
13.00-14.00	**Lunch Break**	
14.00-14.30	**Summary & Way Forward**	Dr. Krishnan Srinivasaraghavan, APCTT-ESCAP
14.30-14.45	**Workshop Evaluation and Feedback**	Mr. Suraj Pandey APCTT-ESCAP
14.45-15.00	**Concluding Remarks**	NPPC, MoAF

Annex 3: List of Participants

List of Participants- SATNET Training Programme on Bio–intensive Pest Management in Economically Important Agricultural Crops, 24-25 February 2014, Thimphu, Bhutan

S.No	Name of the participant	Organization	DESIGNATION	Email ID/Mobile No	Place
1	Ms. Delma	Dzongkhang Administration	Senior Extension officer	Delma2011@hotmail.com 17826892	Paro
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List of Participants- Training Programme on "Mass Scale production of Bio-control Agents and Establishing a Bio-control Laboratory, 26-28 February 2014, Thimphu, Bhutan

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