Funded by

USAID FROM THE AMERICAN PEOPLE

BILL & MELINDA GATES foundation

CSISA

Partners

CIMMYT International Maize and Wheat Improvement Center

IFPRI

IRRI

INTEGRATED WEED MANAGEMENT IN RICE

TRAINING OF TRAINERS MODULES

2017

The Cereal Systems Initiative for South Asia (CSISA) is a regional initiative to sustainably increase the productivity of cereal-based cropping systems, thus improving food security and farmers' livelihoods in Bangladesh, India and Nepal. CSISA works with public and private partners to support the widespread adoption of resource-conserving and climate-resilient farming technologies and practices. The initiative is led by the International Maize and Wheat Improvement Center (CIMMYT), implemented jointly with the International Food Policy Research Institute (IFPRI) and the International Rice Research Institute (IRRI), and is funded by USAID and the Bill & Melinda Gates Foundation.

www.csisa.org

email: cimmyt-csisa@cgiar.org

Contributors: Virender Kumar[1], Ashok Yadav[1], R. K. Malik[2], P. Panneerselvam[1], Ajay Kumar[2], Krupnik, T.J[2], B. N. Das[3], Shantanu Dubey[4], U.S. Gautam[4], Anjani Kumar[5], J.S. Mishra[6], Himanshu Pathak[7], G.S. Panwar[8], Arvindo Das[9], Sanghamitra Pattnaik[9], Sudhanshu Singh[1], Andrew McDonald[2]

1 International Rice Research Institute (IRRI). 2 International Maize and Wheat Improvement Center (CIMMYT). 3 Institute on Management of Agricultural Extension (IMAGE), Government of Odisha. 4 Agricultural Technology Application Research Institutes (ATARI) Kanpur. 5 ATARI Patna. 6 ICAR-RCER Patna. 7 National Rice Research Institute (NRRI) Cuttack. 8 Bihar Agricultural University (BAU) Sabour. 9 Orissa University of Agriculture and Technology (OUAT).

This publication was made possible through the support provided by the United States Agency for International Development and the Bill & Melinda Gates Foundation. The contents and opinions expressed herein are those of the author(s) and do not necessarily reflect the views of USAID or the Gates Foundation.

Published in July 2017

This publication was adapted from:
Krupnik, T.J., Naher, K. Islam, S., Hoque, M.A., Roy, A., Kumar, V., Hossain, I., Hossain, K., Shahrin, S., Gathala, M.K., Shrestha, A., Uddin, S.M.N. 2016. Integrated weed management: Experiential learning modules. Mexico, D.F.: CIMMYT.

TABLE OF CONTENTS

OVERVIEW OF THE TRAINING MODULE

INTRODUCTION

In India, weeds are responsible for about 33% of total yield losses caused by pests, whereas insects and diseases are responsible for 26% and 20%, respectively. Weeds interfere with crops by competing for light, water, nutrients and space resulting in reduction of crop yield and quality. The yield reduction in any crop through weed competition depends on several factors such as weed flora and density, duration of competition, management practices and climatic conditions. Therefore, timely weed management is crucial for attaining optimal grain yield of a crop. However, none of the single weed control methods are effective for all weeds and to manage weeds effectively and sustainably in the long run, it is essential to develop and deploy flexible integrated weed management (IWM) practices. IWM consists of physical, cultural, chemical, and biological means (Figure 1) developed on knowledge of weed ecology and biology.

In addition, costs involved in weed management constitute a significant share of total cost of production. Weeds have also become major constraints in adoption of new resource-efficient (labor, water, and tillage) technologies such as direct-seeded rice and reduced/zero-till systems. In eastern India, hand weeding has traditionally been the most common practice of weed control in rice and other cereals crops. In recent years, because of rising scarcity of labor and increasing labor wages, farmers have started adopting herbicides for weed control. However, farmers have limited knowledge on proper herbicide handling, selection of herbicide molecules and their time of application, application technologies for better efficacy, and environmental and human health risks associated with their incorrect use. Therefore, there is a need to train and develop master trainers with a strong understanding of IWM, who will help to pass on this knowledge on to farmers.

This training module covers critical topics on the principles and practices of IWM, in the context of Indian agriculture, where the majority of farmers are smallholders. Strong emphasis has been placed on hands-on learning and learning by experience. This module aims to provide guidance to the training facilitators to conduct rapid two-day trainings on IWM, including step-by-step detailed instructions on how to facilitate the training, training materials required for successfully conducting different sessions, and instructions on how to conduct hands-on trainings, field visits and practical sessions. IWM principles can be better learned through multiple training sessions combined with practical sessions, or as part of a farmer field school than a single classroom session covering different aspects of IWM. Hence, while this module covers five training sessions that can be conducted consecutively over two days, they can also be delivered as individual modules, for example, during a season-long farmer field school.

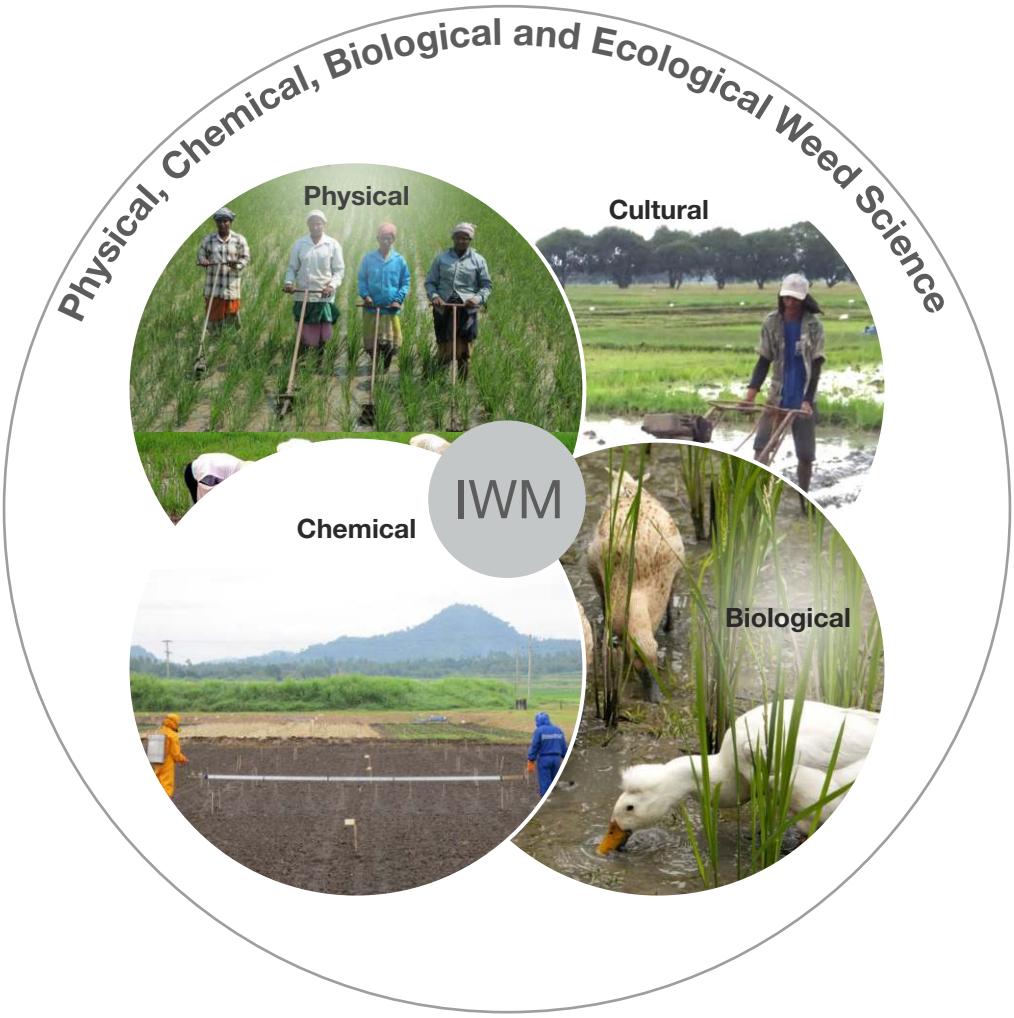


Figure 1. Components of Integrated Weed Management

TARGET GROUPS FOR THIS TRAINING

- Extension agents
- Local service providers
- Local pesticide applicators
- Progressive farmers interested in understanding and/or practicing improved weed management and efficient herbicide application technologies

ORGANIZATION OF THIS MODULE

This module is organized into five independent learning sessions and designed to be covered over two days:

1.	**Introduction and training objectives (Session I)**
2.	**Know your weeds — Getting acquainted with important weeds of rice (Session II)**
3.	**Integrated weed management options (Session III)**
4.	**Improved herbicide spraying and handling techniques — Accurate, efficient and safe herbicide spraying techniques, sprayer calibration, safe handling and personal protective equipment (Session IV)**
5.	**Review key take-home messages, Q&A session, post-evaluation discussion, and feedback on training from participants (Session V)**

For each of these sessions, step-by-step instructions are given for training facilitators on how to implement each session. This includes: key learning objectives, key messages to be given to the participants, materials required to conduct the session, and instructions on how to conduct sessions with hands-on learnings and practical demonstrations. For each session, a PowerPoint presentation on the topic is included (see Annex 3), which should be used by the facilitator. All participants should be engaged in the discussion and encouraged to speak and ask questions, especially under-represented participants such as women. The PowerPoint presentation and other relevant reference materials can be printed and provided as handouts to the participants.

Participants' current knowledge should be evaluated by conducting a pre-test just before the training begins. To assess the learning progress of participants, a post-evaluation should be conducted at the end of the training. Pre- and post-test exam sheets have been included as Annex 1 and 2 for ready reference.

TRAINING AIMS AND OBJECTIVES

By the end of the training, participants should be able to:

- ✓ Understand and explain the importance of weed management
- ✓ Differentiate grass, broadleaf and sedge species, identify key weed species of rice and understand the importance of weed identification
- ✓ Know different methods of weed control and understand the importance of integrated weed management
- ✓ Know different type of herbicides, specific herbicides to control different weed species, their doses and time of application, and safe handling and accurate application technologies for effective, economic and environmentally safe weed control
- ✓ Know different types of nozzles used for pesticide application and nozzles suited for herbicide application
- ✓ Understand the importance of uniform coverage and concept of boom sprayer
- ✓ Know how to calibrate the sprayers properly
- ✓ Understand the scope of providing service of herbicide spraying as a business

KEY CONSIDERATIONS FOR TRAINING

The facilitator or training coordinator should consider the following to ensure effective and successful implementation of the training:

Participants	Keep the number of participants per batch limited to a maximum of 20-25 with a good mix of male and female participants.
Venue	Training centers or any institute with fields/farms within walking distance so that all hands-on sessions can be demonstrated to the participants in the field and participants get a chance to learn the IWM practices by doing, as this will allow the participants to understand the process completely. Each session will consist of a classroom lecture followed by hands-on training in the field.
Training material	Ensure that all the training materials listed at the beginning of each module are arranged and available in the proper quantity and in working condition. Try to arrange at least one machine, sprayer, or piece of equipment per three to five participants so that the opportunity for hands-on learning is increased.
Trainers	Extension agents or field staff who have already received training on IWM can be the trainers/facilitators for this training.
Participants evaluation	A pre-evaluation test of the participants just prior to the beginning of the training session to judge their current knowledge level and a post-evaluation test at the end of all training sessions should be conducted to evaluate the effectiveness of training.
Feedback	Feedback should be taken from all the participants after the completion of each session regarding suggestions for further improvement of the overall training module.

COURSE PREPARATION AND DURATION

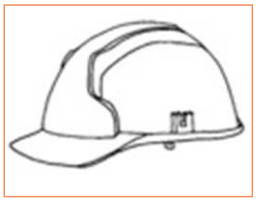
The course is designed to span two days, covering a mix of classroom and hands-on sessions. The content is divided into five instructional sessions followed by Q&A, post-evaluation test and feedback session as follows:

DAY 1			
Session	**Topic**	**Approximate duration (minutes)**	
		Classroom	Hands-on
I	Introduction, training objectives	60	-
II	Know your weeds — a) Getting acquainted with major weeds	90	-
	b) Field visit to identify weeds and to prepare herbarium	-	90
III	Integrated weed management (IWM) options	60	120
DAY 2			
IV A	Improved herbicide spraying techniques including calibration, precautions and maintenance	120	-
IV B	Practical exercise on spraying techniques	-	90
V	Q&A session and post evaluation/feedback	60	-

PLANNING AND PREPARATION FOR THE HANDS-ON TRAINING AND REQUIRED TRAINING AIDS

The suggested duration of this training module is of two days. However, it is not possible to conduct hands-on training unless a few activities are in place before the start of the training. Complete the below mentioned activities beforehand, but do not forget to explain these steps to the participants during the classroom session. Following is the list of activities which need to be completed earlier:

- Demonstration plots with and without weed management. Demo plots should be established well ahead of the training so that they become ready to serve the training on time.
- Selection of a plot infested with major weeds of rice on which training is conducted, or grow major weeds in pots for weed identification.
- Hand weeding tools (like hand hoe or niranee, *khurpi*), mechanical weeders, including manually operated and motorized (if available).
- Two to three different types of backpack pump sprayers (manually operated traditional backpack, battery operated, motorized sprayers) for demonstration if available (if not, simple pump sprayers will do). In addition, two to three knapsack pump sprayers (manual or battery operated) for herbicide application (one for the training facilitator and then one for each group).
- Measuring beaker to measure water (250, 500, 1000ml capacities are ideal)
- 3-4 water buckets of at least 10L each
- Flexible measuring tape (at least 40m length)
- Spray nozzles: 3-4 sets of different types of nozzles (flat-fan type, even cone type, and flood jet/cut type, if available) to demonstrate how these nozzles differ in spray pattern. Make sure they come with strainers.
- Spray booms: 3-4 sets of multiple nozzle booms (e.g. three nozzle booms) fitted with flat fan nozzles, if available. One single nozzle boom is also needed.
- About 1/2 to 1L each of pre-emergent and post-emergent herbicides (select the active ingredient most appropriate for your region, or for the weeds to be controlled).
- Protective clothing (at least 3 sets) for herbicide application, including goggles, a rubber hat, a mask to cover the face, protective polyethylene coat that covers the head and arms, gloves, protective polyethylene trousers, and gumboots, as shown below:



Rubber or plastic safety hat

Goggles

Respirator

Rubber gloves

Rubber boots

Rubber jacket or apron

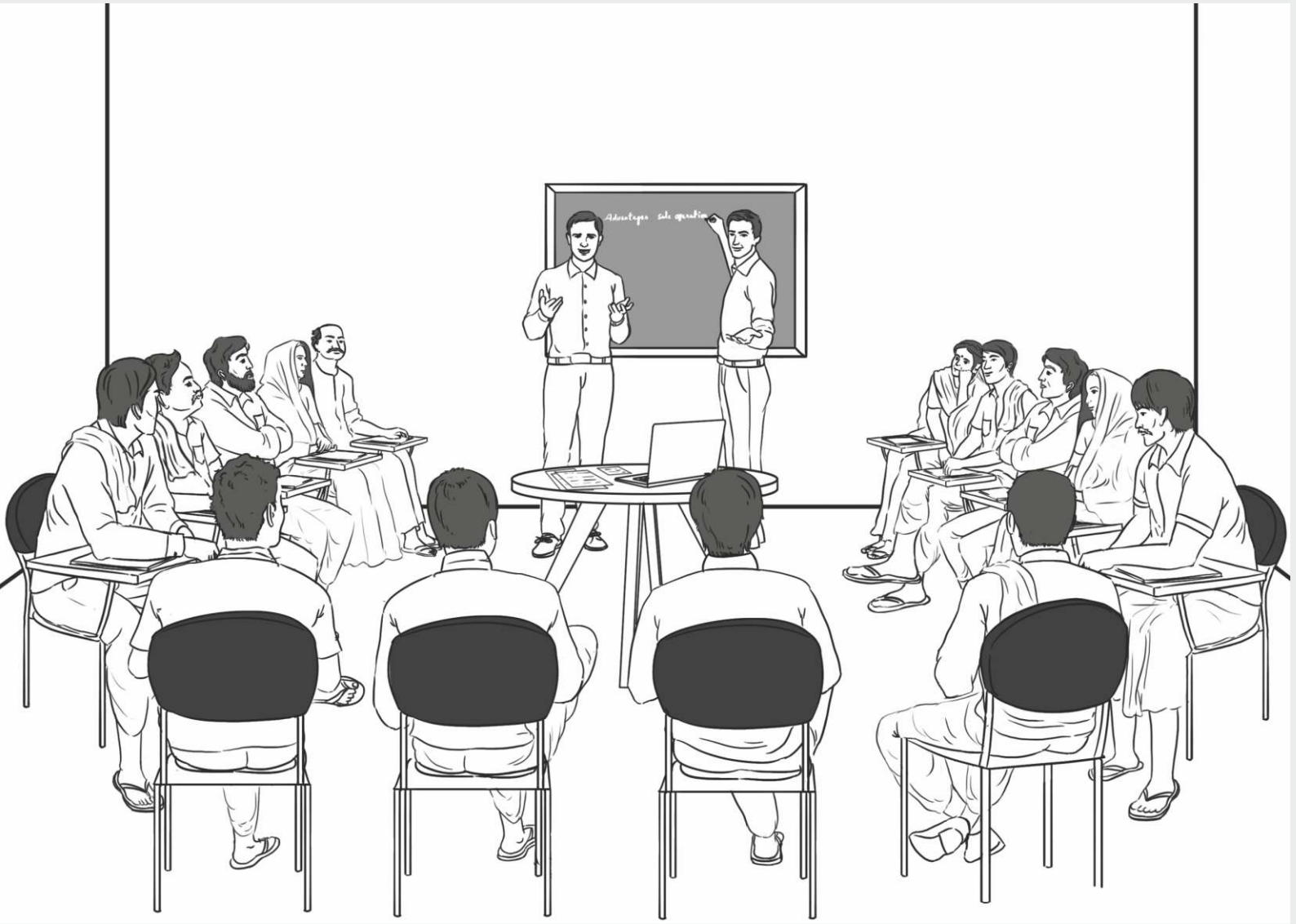
Protective clothing

Photo credit: Integrated weed management: Experiential learning modules - Book 2. Mexico, CIMMYT

FOR CLASSROOM SESSION

- Projector and screen for presentations
- White/black board, duster and markers
- Notebook and pen for each participant
- One printout of the pre- and post-tests for each participant (see the Annexes 1 and 2)
- Handouts (paper versions of the presentations) for each participant (see Annex 3)
- One copy of communication materials and videos for each participant
- Flip charts

SESSION I
INTRODUCTION AND TRAINING OBJECTIVES



LEARNING OBJECTIVES

At the end of the session, participants should be able to:

- Know their fellow participants
- Know the objectives of the training and topics to be covered in the training
- Assess their own knowledge and understand the training guidelines for learning and cooperation

KEY MESSAGES TO BE CONVEYED IN THIS SESSION

- This training is composed of five sessions and will be covered in two days. It will be a mix of classroom lecture and hands-on learning.
- This is a participatory training, and both trainers and trainees will learn from each other.
- The training is mostly hands-on. Participants should learn by working with the IWM principles and equipment themselves rather than just listening. Active participation is the best.
- Participants should be attentive during the training and participate either individually or in groups for each task/assignment given to them.
- All participants as well as facilitators should keep their mobile phone switched-off, or on silent.

STEPS FOR CONDUCTING THIS SESSION

Step 1

Participant introduction and expectations of the training (30 minutes)

Assemble training participants in a classroom and start the session with a welcome. The trainer should give a brief introduction of himself/herself and other resource persons present. Ask the participants to introduce themselves by giving details like occupation and area of operation, and how they are associated with weed management. Also, ask all participants individually what they expect from this training and what they want to learn. It will help the training coordinator make the training more effective by focusing more on those topics participants are interested in. The trainer should list down the expectations on a flip chart.

Step 2

Introduction to today's training program (10-15 minutes)

The training coordinator will then present Session I: Introduction to Integrated Weed Management using a PowerPoint presentation. A pen drive/CD of all the presentations will be provided to the participants. Also, hard copies of the presentation should be handed out to the participants.

Step 3

Pre-test examination (15 minutes)

Distribute the 'pre-evaluation questionnaires' (see Annex 1) to every participant and allow them 15 minutes to answer the questions. Collect the pre-evaluation sheets for later comparison with the post-evaluations at the conclusion of the training. They should be checked/corrected during the course of the day, prior to the closing session.

Note: Please refer to Annex 3 for PowerPoint slides for Session I: Introduction and training objectives.

SESSION II
KNOW YOUR WEEDS

LEARNING OBJECTIVES

At the end of this session, participants should be able to:

- Exchange their knowledge about weeds
- Know why weed control is important
- Understand why knowing about types of weeds is important
- Differentiate between grass, broadleaf and sedge weed species
- Familiarize and identify the major weed species of rice
- Differentiate *Echinochloa* species from other grass weed species

KEY MESSAGES TO BE CONVEYED IN THIS SESSION

- Weeds compete with crops for nutrients, space, light and water and result in yield losses.
- Weeds can be classified into three main groups: grasses, broadleaf and sedges.
- It is important to know the type of weeds infesting your field. Why? Different management strategies are needed for different types of weed species as weeds differ in their response to control measures.
- Yield losses due to weeds in rice are higher under direct seeded and upland rice than in puddled transplanted rice.

MATERIALS NEEDED TO CONDUCT THIS SESSION

- Selection of a field or a demonstration plot near the training venue which contains the main weed species of rice.
- Pots with grasses, broadleaf and sedge weed species. Either grow some major grass, broadleaf and sedge weed species in pots in advance by seeding weeds or by transplanting these weed species in pots from the field. This is to use during classroom lecture to explain differences in broadleaf, grasses and sedges.
- PowerPoint presentation “Session II: Know your weeds” (Annex 3)
- Handout of the presentation
- Flip charts, markers
- Newspaper, knife

STEPS FOR CONDUCTING THE SESSION

Step 1

Initiate the discussion on weeds (group assignment, 35 minutes)

Divide the participants into 4-5 groups. Each group should consist of 4-5 people. After this, initiate discussion on weeds with participants and asks each group to discuss and note down their points on the flip chart around the following:

1. What is a weed?
2. What are different types of weeds? Write down 5-10 major weeds of rice
3. Negative effects of weeds
4. Where are agricultural weeds coming from?
5. Why is it important to know your weeds?

Give the group 15 minutes to discuss and prepare their report and then ask each group to present their report (15 minutes).

Step 2

Knowing your weeds (45 minutes)

In this step, make a presentation using the PowerPoint presentation provided in Annex 3 (Session II: Knowing your weeds). Also, provide handout of this presentation to participants. This presentation covers the following topics: 1) What is a weed?; (2) Why is weed control important?; (3) Losses caused by weeds in rice; (4) Types of weeds; (5) Major grass, broadleaf and sedge weed species of rice; (6) Why is it important to know your weeds?

Use a white board or flip chart wherever needed to explain things.

During this section, ask each group to do a practical exercise to differentiate between grass, broadleaf and sedge weed species. This exercise should immediately follow classroom teaching on different types of weeds (see PowerPoint presentation slide #15 for detailed instructions about this exercise).

If weeds are grown in pots, then after this lecture, show those weeds to participants and explain key characteristics of each weed (if not, then take them to field for hands-on learning).

Step 3

Field visit for hands-on learning (60 minutes)

The training coordinator explains the procedure for the field visit. Divide the participants in 4 groups (keep the same morning groups). Take the participants to either the selected demo plots or a pre-identified field in which the common rice weeds are present. Facilitator then shows the major weeds of rice present in the field, how to differentiate between types of weeds (grasses, broadleaf and sedges) and ask some local names of weeds to engage the participants. After this, the facilitator asks each group to collect 5-10 predominant weed species from that field and classify them into grass, broadleaf or sedge and record their local names and note down their prevalence in the field (minor or moderate or dominant). After this, participants return to the training venue.

Step 4

Participants present their field report (30 minutes)

Facilitator asks participants to arrange their report in the format given below:

Sr. No.	Type of weed (grass/broadleaf/sedge)	Local name of weed	Prevalence in the field (minor/moderate/dominant)
1			
2			

Each group then presents their report and shows the weed they collected and other information they compiled about those weed species in the format.

Note: Please refer to Annex 3 for PowerPoint slides for Session II: Know your weeds.

SESSION III
INTEGRATED WEED MANAGEMENT OPTIONS

LEARNING OBJECTIVES

At the end of this session, participants should be able to:

- Know different rice establishment methods and why weed control is more challenging in direct seeded rice (DSR)
- Know different methods of weed management [cultural, physical (mechanical/manual) and chemical]
- Understand the importance of using an integrated approach to weed management
- Select the appropriate herbicides or their mixtures based on type of weed and time of application
- Understand the weedy rice problem in direct seeded rice and how to tackle it
- Explain the factors affecting shifts in weed flora in rice
- Have knowledge of herbicide resistance evolution in weeds

KEY MESSAGES TO BE CONVEYED IN THIS SESSION

- Rice can be established either by transplanting (manual or mechanical) or direct seeding (broadcasting or line sowing using a seed drill).
- In states like Odisha, broadcasting of rice followed by beushening is also a common rice establishment method. (The training coordinator will use this message only during trainings in Odisha. For other states it is not important.)
- Due to rising labor shortages and increasing labor wages, there is more interest to shift towards labor-saving and cost-effective rice establishment methods such as direct seeded rice or mechanical transplanted rice.
- Weeds are more serious problem in DSR than in transplanted rice because: (1) the initial flush of weeds is not controlled by early flooding because flooding immediately after sowing is not possible in DSR as germinating rice is sensitive to flooding, (2) in DSR, rice does not get headstart compared to weeds as is the case in transplanted rice.
- Weeds should be controlled before they start to compete with rice.
- Minimize weed seed production and seed recruitment in soil. Weed should be removed or controlled before they set seeds.
- Four guiding principles for weed management in any crop are: (1) Know your weeds (see Session II), (2) Keep the crop free from weed competition in first 30-40 days after sowing (DAS) / or transplanting (DAT), (3) Apply weed control properly and at the right time, and (4) Integrate different weed control methods sensibly depending on options and resource availability.
- IWM consists of cultural, physical (manual hand weeding or mechanical weeding), and chemical methods (using the right herbicide at the right dose, at the right time and through the right method of application).
- IWM minimizes the dependence on herbicides and hence reduces the evolution of herbicide resistance in weeds. IWM is more sustainable and effective in the long run than any single method.
- Cultural methods include:
  - Preventing entry of weed seeds to crop fields by using rice seeds free from weed seeds or using seedlings not infested with weeds, cleaning machineries/equipments before entering new fields, and if FYM is being used, it should be well decomposed (avoid using non-decomposed FYM as they can be source of new weeds).
  - By preventing seed production during fallow periods.

  - Using state seedbed techniques
  - Dust or soil mulching (pre-sowing irrigation followed by shallow tillage followed by sowing and then delaying first irrigation for about 10-15 days) in DSR
  - Good land preparation to have fields free from weeds at the time of crop establishment
  - Flooding in transplanted rice (immediately after transplanting for the first 3-4 weeks)
  - Good agronomy methods that give more competitive advantage to rice than to weeds such as competitive cultivars/hybrids, narrow spacing, good fertilizer management, etc.
  - Crop rotation
- Manual weeding is important to remove escaped weeds or noxious weeds, which are not controlled by herbicides. Mechanical weeding can reduce time and labor costs.
- Herbicides can provide effective and economical weed control and save labor. Herbicides play an important role in facilitating the adoption of DSR, but over-reliance on herbicide can lead to herbicide resistance development in weeds and can also adversely affect environment and human health.
- The three major types of herbicides are pre-plant, pre-emergence and post-emergent herbicides.
  - Pre-plant herbicides are used for controlling annual weeds and their application is made before the crop is planted to make the best use of the moisture available at the time of sowing. Some of these herbicides like dinitroanilines need incorporation to avoid volatilization losses. Pre-seed burn down herbicides like glyphosate are mainly used for controlling weeds that have already emerged in the field prior to seeding. These herbicides are especially important under zero-till/conservation agriculture based systems or where time for good land preparation is limited.
  - Pre-emergence herbicides are applied after crop seeding but prior to the emergence of weeds, 1-3 days after seeding or transplanting, by ensuring adequate moisture at the time of spraying.
  - Post-emergent herbicides are applied after the crop and weeds have emerged, generally at leaf stage 3-4 of weeds.
- Select the appropriate herbicides for specific rice establishment methods the types of weeds that are problem in the field (broadleaf, sedge or grass) and time of application (i.e. pre-plant, pre-emergence or post-emergence). The most common herbicide options for transplanted and direct seeded rice are given as in Annex IV.

Note: There are no selective herbicides available for controlling weedy rice, emerging weeds in DSR systems. This can be best managed using stale seedbed techniques (by germinating them prior to rice seeding and killing them), by rotating DSR with transplanted rice (manual or mechanical) and preventing their seed production by removing them before seed setting by manual weeding or cutting their panicles using sickles.

MATERIALS AND RESOURCES NEEDED TO CONDUCT THIS SESSION

- PowerPoint presentation “Session III: Integrated weed management options in rice” (Annex 3)
- Printed copies of the presentation as a handout for each participant
- White board, markers, flip charts
- Identification of three farmers, who have farms nearby the training venue, for a field visit and interaction with farmers
- Newspaper, knife
- Samples of pre-plant, pre- and post-emergence herbicides to control different types of weeds

STEPS FOR CONDUCTING THE SESSION

Step 1

Initiate discussion on different rice establishment methods (30 minutes)

The training coordinator divides the participants into 3 groups and asks them to discuss and list different rice establishment methods prevalent in their area. Give 15 minutes to the groups to discuss the following points: In which method are weeds less of a problem and in which method are weeds more problematic? Under what landscape (upland, lowland) are weeds more or less problem? What are the common weed management practices used by farmers in rice crop in their area and their time of application, e.g. prior to sowing/transplanting, and after sowing/transplanting? Then ask each group to present their discussion outcomes.

Step 2

Integrated weed management in rice (30 minutes)

In this step, the training coordinator will make a PowerPoint presentation (Session III: Integrated weed management options). Make the presentation more interactive by asking questions, allowing participants to ask questions and discussing points participants listed in the first step.

Step 3

Field visit for hands-on experience (100 minutes)

Divide the participants into 3 groups (as done in the first step). The training coordinator briefs the participants about the field visit. Take these groups to the farms of three pre-identified farmers. Each group will interact with one farmer and collect information about rice weed management practices and major weeds at his/her farm. Each group will have the following discussion with the farmer:

1. Farmer details: Name, village, block, district, and mobile phone
2. Rice establishment methods practiced by the farmer
3. What are his/her issues related to weed management?
4. Problematic weeds on his/her farm
5. List important weed management practices used by farmers and map these practices along the crop calendar/crop growth stages/time of application (e.g. during fallow period, just prior to sowing/transplanting, and post sowing/transplanting)
6. Does he/she uses herbicides?
7. If yes, which herbicide/s, their time of application, whether satisfied with performance
8. Are herbicides costly or not? (Record farmer's perception)
9. Are herbicides easily available in the market?
10. How they decide which herbicide to use? From where do they get information (shopkeeper, extension agent, KVKs, State Agricultural University (SAU)
11. Do they use safety precautions while spraying? (using gumboots, gloves, body is fully covered and not exposed to herbicides)

12. How much is the total cost of managing weeds?
13. How much are the losses (%) caused by weeds in rice? (Farmer's perception)
14. Do they want more knowledge and training on weed management?

After this interaction, the group will visit 2-4 plots of his/her farm and collect weeds they find or they think are predominant in those fields. They should collect 5-6 weeds from each plot and record following information:

Plot #	Weed species	Local name	Type of weed (G, B, S)	Field type (Upland/lowland)	Prevalence in the field (minor, moderate, dominant)
1					
2					
3					

Note: G: Grass, B: Broadleaf, S:Sedge

Step 4

Each group presents their report (20 minutes)

The training coordinator asks each group to present their field report (results of their discussion/interview with the farmer and weed information they collected from his/her farm). After each presentation, allow other groups to ask questions.

Note: Please refer to Annex 3 for PowerPoint slides for Session III: Integrated weed management options in rice.

SESSION IV
IMPROVED HERBICIDE SPRAYING AND HANDLING TECHNIQUES

PART 1: HERBICIDE SPRAYING TECHNIQUES

LEARNING OBJECTIVES

At the end of this session, participants should be able to:

- Identify knowledge gaps surrounding accurate herbicide application
- Know which type of nozzles are suited for herbicide application
- Know different types of sprayer available and their suitablility for herbicide application
- Know the correct method of herbicide application
- Identify factors that influence the efficacy of the herbicides

PART 2: SPRAYER CALIBRATION, SPRAYER MAINTENANCE AND STORAGE, OTHER IMPORTANT POINTS

- Know the importance of sprayer calibration and how to calibrate a sprayer
- Know how to calculate the required water/spray volume
- Know how to calculate the herbicide dose or surfactant dose per tank
- Safe handling of herbicide and safety precautions during spraying including personal protective equipment (PPE)
- Know procedure of proper mixing of herbicide
- Know importance of surfactant
- Spray drift problem and how to avoid drift
- Know procedure for proper cleaning of sprayer and its accessories after use
- Proper maintenance and storage of sprayer and chemicals

PART 1

KEY MESSAGES TO BE CONVEYED IN THIS SESSION

1. The current method of herbicide application (single nozzle boom, cone type nozzle and swing method) using knapsack sprayer is non-uniform, leading to poor herbicide efficacy.
2. Different types of sprayers available include the knapsack sprayer and mounted sprayer (e.g. tractor mounted or mounted on another platform). Knapsack sprayers are the most common for smallholders in the tropics.
3. Knapsack sprayers are most commonly used for spraying herbicides on field crops. Three types of knapsack sprayers are often available in the market, including manual pneumatic, motorized pneumatic and battery operated sprayers. Therefore, the major emphasis should be placed on accurate herbicide application technologies using the knapsack sprayer.

Knapsack manual operated

Knapsack manual operated

Knapsack power sprayer

Knapsack battery operated

Cart mounted boom sprayer

Tractor mounted sprayer

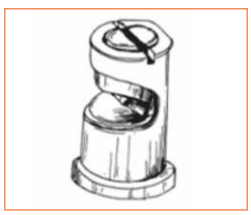
Above: Different types of sprayers (Knapsack and Mounted)

4. Accurate application of herbicide is essential for:
    - Avoiding crop injury
    - Maximizing herbicides efficacy
    - Controlling weeds at the right stage
5. Key components of accurate spray application include:
    - Nozzles
    - Boom type and use
    - Boom height
    - Pressure regulation
    - Use of clean water in the tank
    - Practical calibration
6. For herbicide application, flat-fan nozzles or flood/cut nozzles are recommended. Cone-type nozzles are not suitable for herbicides. Use flat-fan nozzles for multiple nozzle boom and for single nozzle boom; the flood/cut nozzle is more suitable.
7. Multiple nozzle booms improve herbicide efficacy and efficiency by increasing uniformity.
8. Mounted sprayers (e.g. tractor mounted) provide uniform and safe application (applicators are not directly exposed while spraying) and better efficacy.
9. Boom height should be kept at 50cm from the target for uniform herbicide application.
10. Pressure regulation is important for the accurate and uniform application of herbicides. Spraying at a constant pressure is key for uniform application. A normal, manually-operated knapsack sprayer, spray pressure varies with pumping, leading to non-uniform application. Battery-operated sprayers, that create and maintain constant pressure, are better suited for uniform application.
11. Always use clean water for making the herbicide mixture. Dirty/muddy water can reduce the efficacy of some herbicides and lead to intermittent nozzle clogging.

MATERIALS NEEDED TO CONDUCT THIS SESSION

1. PowerPoint presentation, “Session IV: Improved herbicide application and handling techniques”
2. Printed copies of the presentation as a handout for each participant
3. Different types of knapsack sprayers, i.e. manual pneumatic, battery operated and motorized pneumatic (if available)
4. Single and multiple nozzle booms
5. Different nozzle types (flat fan-, cone-, cut/flood jet-type – made of plastic, brass, stainless steel tips)
6. Shield or hood

Fan-flat nozzles



Flood jet

Hollow cone

Photo credit: Integrated weed management: Experiential learning modules - Book 2. Mexico, CIMMYT

STEPS FOR CONDUCTING THIS SESSION

Step 1

Generate reflection and discussion (50 minutes)

Divide participants into 3 groups. Ask each group to discuss and write notes on a flip chart about the following points:

- How herbicides are applied in your area (method of herbicide application)?
- Do farmers do the spraying themselves, or do they hire labor for spraying in their area? What percentage of farmers hire labor for spraying?
- What are types of sprayers used and available for herbicide spraying in your area?
- What type of nozzle you use for herbicide application in your area?
- Are you familiar with different types of nozzles and multiple nozzle boom?
- Do you take safety precautions while handling and applying herbicides in your area?
- If you answered yes to the previous question, then list what safety precautions are taken.
- Does the applicator calibrate the sprayer prior to application?
- Are different types of nozzles and multiple nozzle boom available in the market in your area?

Give participants 20 minutes to discuss these points and then ask each group to present their report (10 minutes each group).

Step 2

Make a Presentation (45 minutes)

Use PowerPoint presentation, “Session IV: Improved herbicide application and handling techniques”. Use a white board to generate discussion and learning around the following points

- Different types of sprayers
- Sprayers suitable for herbicides
- Components of accurate herbicide application
- Nozzle and boom types and application
- Spray swath
- Pressure regulation

During the PowerPoint session, pass the sprayer accessories (e.g. nozzle parts, nozzle types, boom) around for inspection. Allow time for questions and discussion after reviewing each slide, and make sure to complete the session by reviewing the key points and asking participants, if they have questions.

Note: Please refer to Annex 3 for PowerPoint slides for session IV (Part 1): Improved herbicide spraying and handling techniques.

PART 2: SPRAY CALIBRATION, MAINTENANCE AND STORAGE AND OTHER IMPORTANT POINTS FOR IMPROVING HERBICIDE EFFICACY

KEY MESSAGES TO BE CONVEYED IN THIS SESSION

1. Calibration is the process of determining the sprayer output for a known area.
2. Always calibrate your sprayer under field conditions prior to herbicide application. This ensures application of right recommended dose in the field.
3. Walking speed, sprayer tank pressure and nozzle capacity will influence sprayer calibration.
4. Always wear a mask, gloves, coveralls, hat, goggles, gumboots before mixing, preparing, and applying herbicides.
5. Select the appropriate sprayer and nozzles.
6. Make sure constant pressure is maintained in the spray tank and hold the sprayer boom at the right height.
7. Make sure all the nozzles in the boom are of the same type (nozzles are color coded)
8. Explain how to calculate the number of tanks to be sprayed per unit area and herbicide dose per tank.
9. Add surfactants, if prescribed, to improve herbicide effectiveness.
10. Re-calibrate if pressure, nozzles, or speed is changed.
11. Properly mix the herbicide when first put in the tank and keep shaking the tank so that the herbicide remains properly mixed, especially if herbicide is in powder or granule form.
12. The sprayer should be cleaned thoroughly after each use with a brush and detergent in running water. Do not use metal objects for cleaning the nozzle.
13. Minimize spray drift as it can adversely affect neighboring crops, which could be sensitive to that herbicide.
14. The sprayer and herbicides should be stored away from sunlight in a locked room or box. Keep them away from children and animals.

Materials and resources needed to conduct the practical calibration session

- The PowerPoint presentation, “Session IV: Spray calibration, herbicide mixing/handling, spray drift, safety & storage, Part 2”
- Printed copies of the PowerPoint presentation as a handout for each participant
- Blank poster paper/flip chart/white board, marker pen
- A plot of least 33.3m x 3m for a practical exercise on calibration
- Protective clothing (at least 3 sets or one per group) for herbicide application, including goggles, a mask to cover the face, protective polyethylene coat that covers the head and arms, gloves, protective polyethylene trousers, and gumboots
- Different types of knapsack sprayers and four knapsack sprayers (ideally around 15 L capacity), one for each group so each group can have hands-on learning
- Three measuring beakers of 1000 ml capacities to measure water
- At least four flat fan/flood jet nozzles, ideally with multiple booms

- Several flat fan nozzles (for four knapsack sprayers and if using 3 nozzle booms, 12 flat fan nozzles would be needed)
- At least 12 empty plastic bottles
- Duct or electrical tape to attach bottles to nozzles and booms
- 1 kg Urea
- Measuring tape
- Appropriate herbicides for the weeds present in the field (preferably pre-plant or pre-emergent)

STEPS FOR CONDUCTING THIS SESSION

Step 1 (30 minutes)

Make a Presentation

Use PowerPoint presentation (Session IV: Spray calibration, herbicide mixing/handling, spray drift, safety & storage, Part 2). Use the white board for doing calculations related to calibration, calculating the number of tanks/ha to be sprayed and herbicide amount/tank.

Step 2 (10 minutes)

Ask participants to solve the following questions

Q1: During sprayer calibration, 6 liter of water were consumed covering 200 m^2 area. What is the sprayer output (amount of water) per ha?

Q2. How many tanks will be needed to spray 2 acres if the tank capacity is 15 liters?

Q3. If it is recommended to use surfactant @ 0.25% by volume. How much surfactant per tank is needed if a spray tank is of 15 liter capacity?

Step 3 (60 minutes)

Hands-on calibration exercise and experiential learning

Take the participants to the practical demonstration site. Demonstrate the procedure of practical calibration by taking the help of volunteers with focus on the following:

- The spray pattern of different types of nozzles (flat fan, cone type and cut type)
- Spraying using manually operated and battery operated sprayers and discuss the advantage of battery operated sprayers (ease of operation, uniform pressure and uniform herbicide application)
- The uniformity of spraying using multiple nozzle boom as compared to single nozzle boom
- The effect of height of boom on uniformity of spray application
- The swath of single nozzle boom using flat fan and cut nozzle that cut nozzle give wider swath and is more uniform over the entire swath area, therefore is preferred if single nozzle boom is being used
- Select test area for calibrating a sprayer: mark an area of 3 m wide and 33.3 m long (100 m^2) area using a measuring tape.

- Select the appropriate sprayer and nozzle: knapsack sprayer of 15 liter capacity with multiple nozzle boom fitted with flat fan nozzle tips. Remind the participants to check that all nozzle tips are the same type and check that the spray pattern of all nozzle tips are normal. If spray pattern from any nozzle tip is abnormal, it could be due to a blockage or nozzle tip damage. Adjust the nozzle tip fitting on the boom so that they overlap each other.
- Pour the measured amount of water into the tank.
- Calculate the water/spray volume used in spraying selected area (Initial water volume in tank – water volume left in the tank after spraying). Calculate the water volume per ha or acre.
- Discuss how to adjust the spray volume, if needed.

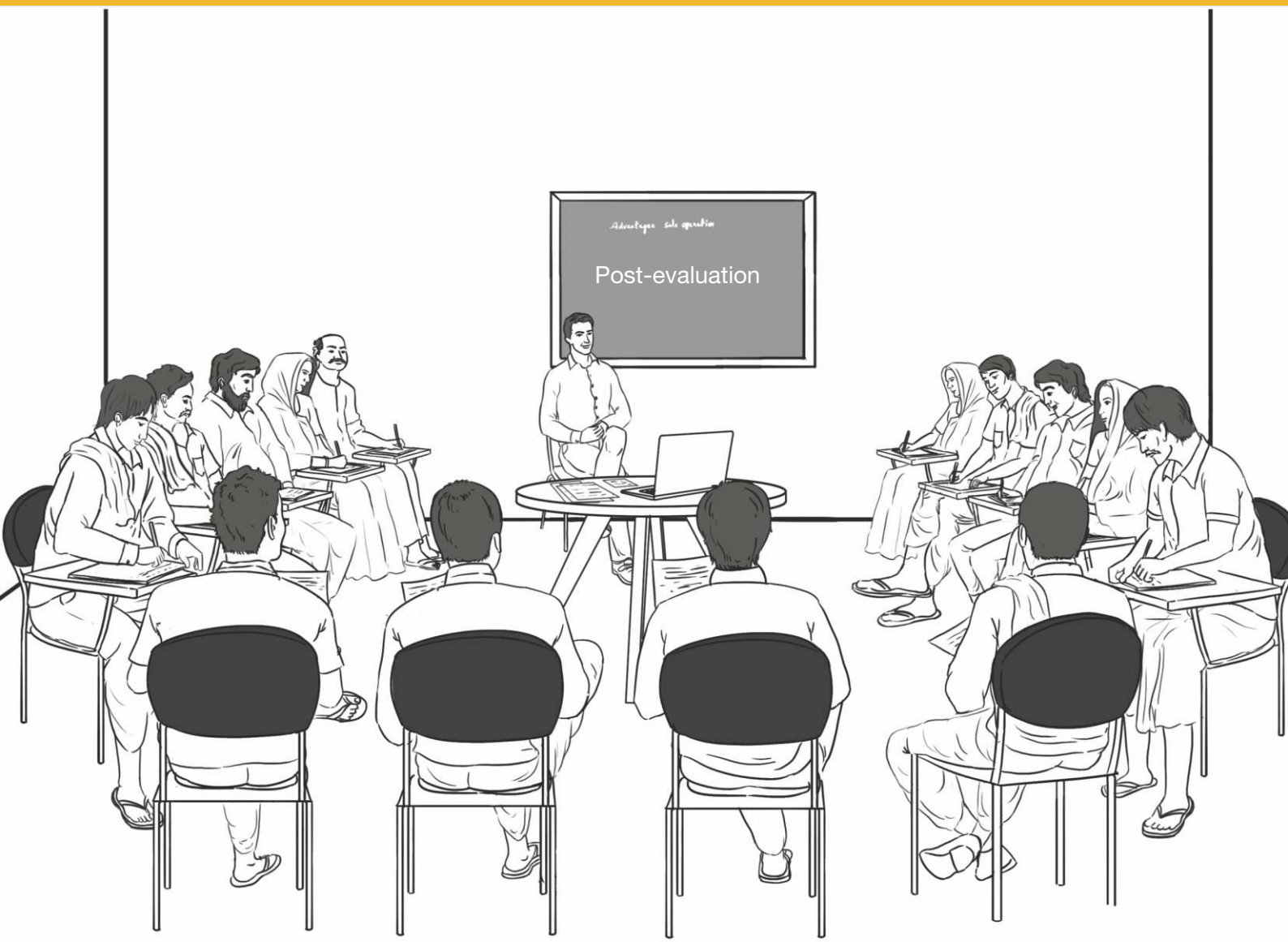
Step 4 (30 minutes)

Group exercise. Divide participants into 4 groups. Ask each group to do the calibration exercise as done in step 3 and ask each group to calculate the water /spray volume/ha.

Before doing this, ensure that they have put on protective clothing correctly.

Note: Please refer to Annex 3 for PowerPoint slides for Session IV (Part 2): Spray calibration, herbicide mixing/handling, spray drift, safety & storage.

SESSION V
REVIEW, Q&A SESSION, POST-TEST AND FEEDBACK



LEARNING OBJECTIVES

At the end of this session, participants should be able to:

- Demonstrate sufficient knowledge of IWM from the previous sessions

MATERIALS REQUIRED

- The PowerPoint presentation "Session V: Review/Key take-home messages, Q&A, Post-evaluation test and closing"
- Print outs of the post evaluation form (Annex 2)
- Training or project logbook (if any)
- Pencils for participants
- Some weed samples (mix of grass, broadleaf and sedge)
- Different type of nozzles

HOW TO CONDUCT THE REVIEW, POST-EVALUATION TEST AND CLOSING OF THE TRAINING (60 MINUTES)

Step1

Review IWM material

First review the PowerPoint presentation. You will notice that the PowerPoint presentation has questions. This is because the training coordinator should ask participants these review questions and help them answer them, and correct any wrong answers.

Step 2

Conduct the post-test

Distribute the post-evaluation forms to participants. Allow them to answer the questions in about 15 minutes. Calculate their scores, and check them compared to their pre-test. Give both pre- and post-evaluation forms back to the participants for review. Also record each participant's score in a training or project logbook. If any errors are common, take time to discuss them with participants and to correct any misconceptions before closing the training.

Step 3

Discuss the opportunity to create custom hiring pesticide applicators

Discuss with participants the advantages of creating skilled/professional pesticide applicators for giving services on a custom hiring basis (easy to train, fewer people to train, better efficacy, business opportunities for youth).

Also, discuss who could be the potential target groups for creating: Service providers using knapsack sprayers and service providers using mounted sprayers.

Step 4

Q&A and close the training

Open the session for Q&A if the participants have any further questions for training coordinator. Ask each participant to complete the feedback form and give a vote of thanks to all the participants for their active participation.

Note: Please refer to Annex 3 for PowerPoint slides for Session V: Review/ key take-home messages, Q&A session, post-test, and closing

ANNEX 1: PRE-EVALUATION FORM

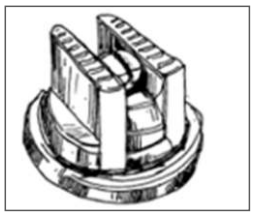
Integrated Weed Management: Farmer and Service Providers' Training Pre-evaluation Form

Venue: **Batch:** **Date:**

Name of trainee:_____

Please put tick (✓) mark on the correct answers **Total time: 10 minutes**

Question	Answer		
 Echinochloa crusgalli 1. This weed belongs to which category:	Sedge	Grass	Broadleaf
 Sphenoclea zeylanica 2. This weed belongs to which category:	Sedge	Grass	Broadleaf
 Cyperus rotundus 3. This weed belongs to which category:	Sedge	Grass	Broadleaf
4. Which is not an appropriate nozzle for herbicide application?	Flat fan	Flood jet	Hollow cone
5. Pretilachlor herbicide in rice is applied as...	Pre-emergence	Post-emergence	Pre-plant as burn down
6. How much overlap in spray swath should be there with a multiple spray boom?	30%	100%	50%
7. Which among them is a post-emergence herbicide?	Bispyribac	Butachlor	Pendimethalin

8. At what height should the sprayer be kept from the target while spraying?	25 cm	50 cm	30 cm
9. If a spray boom is fitted with 3 nozzles spaced 50 cm apart, what would be the spray swath (coverage area in width)?	100 cm	150 cm	200 cm
 10. Which type of nozzle tip is this?	Hollow cone type	Flat fan	Cut type

ANNEX 2: POST-EVALUATION FORM

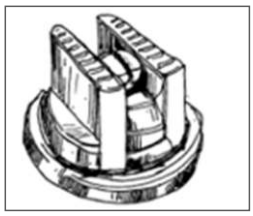
Integrated Weed Management: Farmer and Service Providers' Training Post-evaluation Form

Venue: **Batch:** **Date:**

Name of trainee:_____

Please put tick (✓) mark on the correct answers **Total time: 10 minutes**

Question	Answer		
 Echinochloa crusgalli 1. This weed belongs to which category:	Sedge	Grass	Broadleaf
 Sphenoclea zeylanica 2. This weed belongs to which category:	Sedge	Grass	Broadleaf
 Cyperus rotundus 3. This weed belongs to which category:	Sedge	Grass	Broadleaf
4. Which is not an appropriate nozzle for herbicide application?	Flat fan	Flood jet	Hollow cone
5. Pretilachlor herbicide in rice is applied as...	Pre-emergence	Post-emergence	Pre-plant as burn down
6. How much overlap in spray swath should be there with a multiple spray boom?	30%	100%	50%
7. Which among them is a post-emergence herbicide?	Bispyribac	Butachlor	Pendimethalin

8. At what height should the sprayer be kept from the target while spraying?	25 cm	50 cm	30 cm
9. If a spray boom is fitted with 3 nozzles spaced 50 cm apart, what would be the spray swath (coverage area in width)?	100 cm	150 cm	200 cm
 10. Which type of nozzle tip is this?	Hollow cone type	Flat fan	Cut type

Annex 1 and 2: Answers to pre- and post-test questions

1	Grass	2	Broadleaf	3	Sedge	4	Hollow Cone	5	Pre-emergence
6	30%	7	Bispyribac	8	50 cm	9	150 cm	10	Flat fan

ANNEX 3: POWERPOINT SLIDES

Session I

Introduction and Training Objectives

Training on Integrated Weed Management (IWM)

Welcome and Introduction

- Introduction of participants
  - Name
  - From which place/district/state
  - Occupation
  - Your role in weed management
  - Expectation from this training (list down on a flip chart)

Sessions Schedule

DAY 1

I: Introduction and pre-test

II: Getting acquainted with major weeds (Weed ID)
- Classroom lecture
- Field visit to identify weeds and to prepare herbarium

III: IWM options in major crops
- Classroom lecture
- Visit to demonstration plots and discussion

Day 2

IV Part 1: Improved herbicide spraying techniques including calibration, precautions and maintenance

IV Part 2: Practical exercise on spraying techniques

V: Q&A session and post evaluation/feedback

Training Principles

- This is a participatory training
- Learn by experience: we encourage you to involve yourself fully in hands-on components
- Discuss with each other and learn from each other's experiences

We encourage you to speak and ask questions

Learn and Enjoy!

- Feel free to ask questions and to contribute your knowledge!
- Make sure you get time to practice all hands-on sessions (e.g. calibration of a sprayer and spraying herbicide using a backpack sprayer)!
- Have fun!

Training Rules

Rule # 1

Please keep your mobile phone switched-off, or on silent mode. for urgent calls, go outside to answer the call

Rule # 2

No working on laptops please

7

Session II

Knowing Your Weeds

Start with a Exercise

- Divide participants into 4-5 groups with each group consisting of 4-5 people. Ask participants to discuss the following points and note down their points on flip charts:
  - What is a weed?
  - What are different types of weeds? List 5 major weeds of rice
  - What are negative effects of weeds?
  - From where weeds are coming in the agricultural fields?
  - Why is it important to know your weeds?

Give 15 minutes to discuss the above points to each group
Each group then presents their report (5 minutes to each group to present)

9

What is a Weed?

- **Weed** is a plant growing where it is not desired

or

- **Weed** is "a plant out of place" (WSSA, 1956)

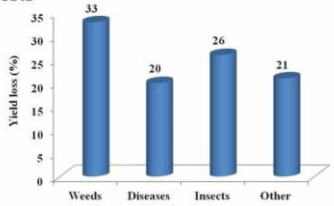
or

- "Plants that interfere with the growth of desirable plants and that are unusually persistent and pernicious. They negatively impact human activities and as such are undesirable" (Ross & Lembi 1999)

10

Why is Weed Control Important?

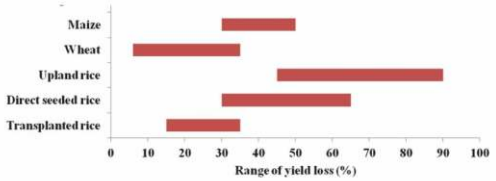
- Weeds compete with crop for resources and hence cause yield losses
  - Water, light, nutrients and space
  - In India, yield losses are higher due to weeds than other pests



Why is Weed Control Important?

- Reduces quality of produce
- Creates problem in harvesting
- Harbors insects and diseases of crops

Losses Due to Weeds in Rice



- Yield losses in rice varies in the following order: Transplanted rice in lowland < direct seeded rice < upland rice
- In Bihar and Odisha: ~25% yield reduction due to weeds in rice

13

Types of Weeds

Type	Grasses	Sedges	Broad-leaved
Leaf shape	long and narrow		various shapes and sizes
Vein arrange-ment	parallel		Netted (Dicot) / Parallel (Monocot)
Stem (cross section)	Solid node, hollow internode		Round or square and solid

Solid and triangular

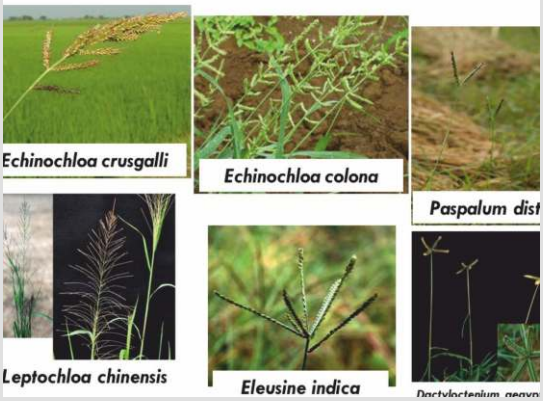
14

Practical Exercise

- Provide weed samples to each group (2-3 samples of grass, broadleaf and sedge)
- Ask each group to cut their stem and record the shape of stem
- Ask them to classify weed samples given to them into grass, broadleaf and sedge types
- One person from each group will present their weeds

Major Weeds of Rice

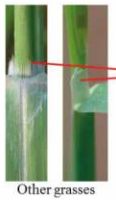
(A) Grasses



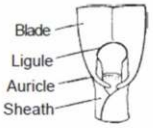
Echinochloa Species Versus Other Grasses

Echinochloa species
- Ligule absent
- Auricle absent

Other grasses
-Ligule present
-Auricle may or may not present



Other grasses



Terminology

Ligule present (hairy or membranous)

18

(B) Broadleaved


Sphenoclea zeylanica


Caesulia axillaris


Eclipta alba


Monochoria vaginalis


Alternenthera sessils


Ludwigia

19

(B) Broadleaved


Sagittaria spp


Commelina benghalensis


Ageratum conyzoides

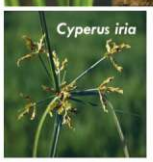
20

(C) Sedges


Cyperus rotundus


Cyperus difformis


Fimbristylis spp


Cyperus iria

21

Why is it Important to Know Your Weeds?

- Accurate weed identification is essential for weed control because weeds differ in their responses to control measures
- Example: Bispyribac is excellent on *Echinochloa* species (grass weed) but it is weak on *Leptochloa* and other grass weed species
- Flooding is effective against many weed species but some species such as *Sphenochloa zeylanica, Monochoria vaginalis* and *Cyperus difformis* are not controlled by flooding

22

What Makes a Plant Weed? (Key Characteristics of a Weed)

Weed species	Maximum seeds/plant (#)
Grasses	
Echinochloa crus-galli	80000
Dactyloctenium aegyptium	66000
Eleusine indica	137000
Ischaemum rugosum	40000
Broadleaved	
Eclipta prostrata	17000
Trianthema portulacastrum	52000
Amaranthus spinosus	235000
Sphenoclea zeylanica	25000
Ludwigia hyssopifolia	250000
Sedges	
Cyperus difformis	50000
Cyperus iria	5000
Fimbristylis miliacea	42000

- High seed production
- Persistent seedbank (dormancy and longevity)
- Germination in flushes
- Highly competitive
- Seed shattering
- Adapted to diverse conditions
- Has mechanisms to disperse/spread (short to long distance)

23

Field Visit for Hands-on Learning Experience

- Divide participants in 4 groups (keep same morning groups)
- Take the participants to selected demo plot or a pre-identified field for hands-on weed ID exercise.
- (See full instruction in session II step 3 & 4)

24

Session III

Integrated Weed Management Options in Rice

Start with Group Discussion (30minutes)

- Divide participants into 3 groups
- Ask each group to discuss and write down their notes on flip charts on following points:
  - Enlist different rice establishment methods prevalent in their working area
  - In which establishment method weeds are less problem and in which method more problem
  - Under what landscape (upland, lowland) weeds are more problem
  - Common weed management practices in rice prior to rice establishment and after crop establishment

15 minutes for discussion
15 minutes for presentation (5 minutes presentation by each group)

26

Methods of Rice Production

- Transplanted rice
  - –Manual transplanting
  - –Mechanical transplanting
- Direct seeded rice
  - –Broadcasting
  - –Broadcasting followed by beushening (in Odisha)
  - –Drill seeding

DSR vs Beushening

(This slide is applicable for Odisha only)

Manual Broadcast with Beushening	Drill seeded rice
• More labor intensive	• Less labor intensive
• More drudgery	• No drudgery
• Higher seed rate (40-50 kg/acre)	• Less seed rate (12-15 kg/acre)
• Higher risks of yield losses due to weeds if beushening is delayed due to delay in rain	• Elimination of beushening Weed control is not dependent on it.
• Higher cost of production	• Savings in cost of production

Manual Broadcasting with Beushening

(This slide is applicable for Odisha only)

- Cross ploughed using bullocks or even mini-tillers
- Women perform the final establishment operation of rearranging the seedlings by placing left over healthy ones at desirable distances (Drudgery)
- Beushening is rain dependent and if rain get delayed, more losses due to weed competition
- Need alternative option for weed control

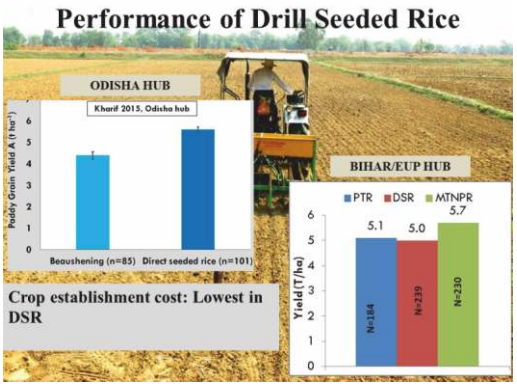
Direct Seeded Rice: Drill Seeding

1. IN DRY FIELD:
Seeding in dry field followed by irrigation or rainfall

2. IN MOIST FIELD (Vattar condition):
Field preparation in vattar condition (after rainfall or irrigation) and then shallow tillage and then seeding

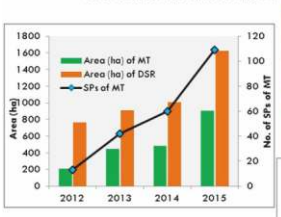
Early weed control by integrating herbicides and hand weeding or mechanical weeding + improved fertilizer management

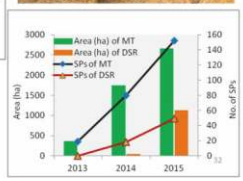
Performance of Drill Seeded Rice



Crop establishment cost: Lowest in DSR

Scaling Mechanized Rice Establishment Methods with Service Providers





In 2016, CSISA supported service providers provided DSR service to 6,530 farmers, covering area of 5,334 ha in Odisha, EUP and Bihar hub domain.

Weeds are Major Problems in DSR

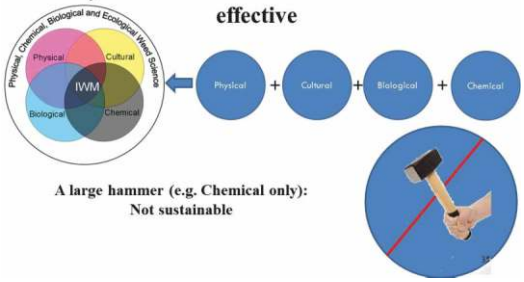
- Initial flush of weeds is not controlled by flooding
- In DSR, crop does not get head start compared to weeds as is the case in transplanted rice

What is Integrated Weed Management?

- It is integration of several different weed control methods, rather than relying on herbicides only
- No single weed control method is effective and sustainable against all weeds
- If only herbicide is used, weeds become resistant
- IWM is a many little hammer approach rather than a large hammer approach

IWM

Many little hammers: more sustainable and effective



A large hammer (e.g. Chemical only): Not sustainable

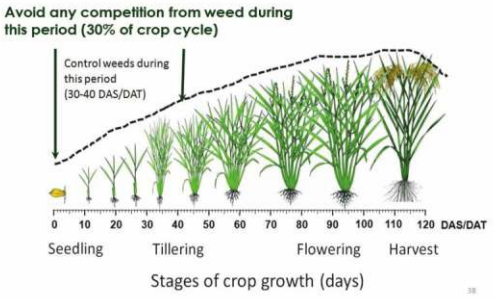
Weed Control in Rice

- Hand weeding has traditionally been the most common weed management practice
- However, because of rising labor scarcity at critical times, hand weeding is either delayed or insufficient, and becoming uneconomical
- Farmers have started adopting herbicide based weed control and in future it will further increase
- Most farmers have limited knowledge on proper herbicide handling, selection of appropriate herbicide molecules and proper application technologies and safety
- Access and availability of new herbicide molecules and spraying accessories or mechanical tools in the market are other issues

Guiding Principles for Weed Management

- Know your weeds
- Accurate weed identification is essential for weed control: because weeds differ in their responses to control measures
- Control weeds in the first 30-40 DAT/DAS
- Apply weed control properly and at the right time
- Integrate intelligently

When is the Best Time to Control Weeds?



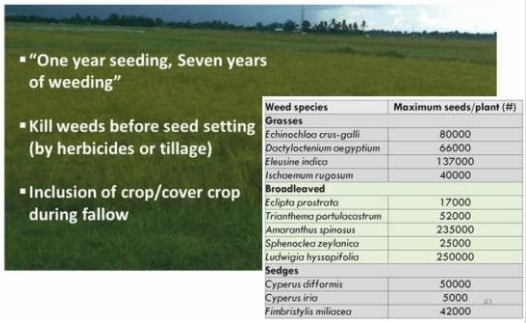
Components of IWM

- Cultural method:
  - Preventing weed seeds to enter the crop fields
  - Fallow management
  - Stale seedbed techniques
  - Good land preparation and dust mulching
  - Water management- Flooding
- Physical method:
  - Manual weeding/Mechanical weeding
- Chemical method:
  - Herbicides (right herbicide, right dose, right time, right method)

Cultural Methods

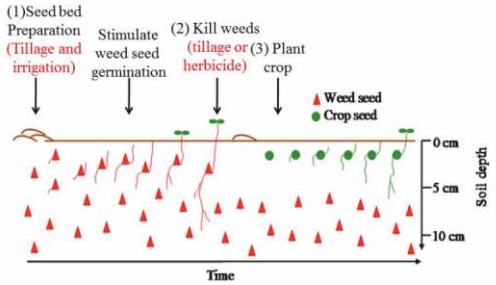
Preventing Weed Seeds to Enter the Crop Fields

Fallow Management



Weed species	Maximum seeds/plant (#)
Grasses	
Echinochloa crus-galli	80000
Dactyloctenium aegyptium	66000
Eleusine indica	137000
Ischaemum rugosum	40000
Broadleaved	
Eclipta prostrata	17000
Trianthema portulacastrum	52000
Amaranthus spinosus	235000
Sphenoclea zeylanica	25000
Ludwigia hyssopifolia	250000
Sedges	
Cyperus difformis	50000
Cyperus iria	5000
Fimbristylis miliacea	42000

Stale Seedbed Techniques



- Important to reduce weed pressure in DSR
- Effective for weedy rice control

43

Dust Mulching

Pre-sowing Irrigation

Shallow cultivation to kill pre-germinated weed seeds and create dust mulch on top 2-3 cm soil.

Rice sowing in vattar condition and delay first irrigation for ~ 2 weeks

Possible if irrigation facilities are available

44

Other Cultural Practices

- Good land preparation and proper leveling
  - Dry tillage/ploughing in summer to kill established weeds. More effective because of dry period following tillage which create conditions for desiccation of uprooted weeds
  - Puddling in transplanted rice- also helps in killing weeds
  - If weed pressure is high especially perennial and tillage is delayed till rainy season starts, applying non-selective herbicide such as glyphosate (1-2 days prior to tillage) followed by tillage has been found effective in killing existing weeds than by tillage alone
- Flooding: In transplanted rice, immediately after transplanting for first 2-4 weeks
- Line sowing: to make hand weeding and mechanical weeding easy
- Good agronomy (optimum fertilizer at right time with split application, closer spacing, weed competitive cultivars)

45

Physical Methods

Hand-weeding/ Mechanical weeding

Chemical Method (Herbicides)

- **Three types of herbicides:**
  - **Pre-plant (burn down herbicides):** These herbicides are non-selective and are applied before you sow the crop to kill the existing weeds. Applied under zero-till systems or where time to prepare good land preparation is limited. Examples: Glyphosate, paraquat
  - **Pre-emergence:** These herbicides are applied after crop seeding but prior to emergence of weeds, 1-3 days after seeding or transplanting, by ensuring adequate moisture at the time of spray. Examples: Pretilachlor, butachlor
  - **Post-emergence:** These herbicides are applied after the crop and weeds are emerged, generally at 3-4 leaf stage of weeds. Examples: Bispyribac, 2,4-D, Almix

47

Chemical Control in Transplanted Rice

- Pre-emergence (Before emergence of weeds)
  - Pretilachlor 50 EC (Rifit, Eraze) 600 ml/acre
  - Butachlor 50 EC (Machete) 1200 ml/acre

Note:

1. Apply any one of the above 2-3 days after rice transplanting in standing water
2. Method of application: mix in sand and broadcast uniformly

48

Chemical Control in Transplanted Rice

(see Annex 4 for full details)

- Post-emergence (After emergence of weeds)

  For mixed weed flora:

  – Bispyribac (Nominee Gold, Adora or Taarak) 80 ml/acre
  – Penoxsulam (Assert or Granite): Assert (400 ml/acre) or granite (38 ml/acre). Assert formulation is best for post-emergence.
  – Bispyribac (Nominee Gold, Adora or Taarak) + pyrazosulfuron (Sathi) 80 ml + 80 g/acre
  – Penoxsulam + cyhalofop (Vivaya): 900 ml/acre
  – Fenoxaprop with safener (Ricestar)+ ethoxysulfuron (Sunrice) 350-500 ml + 48 g/acre

  Note:

  1. Time of application: 15-25 DAT (2-4 leaf stage of weeds)
  2. Method: Spray using 120-150 litre water for one acre (8-10 tanks/acre) using flat fan or cut nozzle

One need base hand weeding to remove escaped weeds

49

Chemical Control in Direct Seeded Rice

- Pre-emergence
  – Pretilachlor + safener (sofit or Eraze-N) 600 ml/acre
  – Oxadiargyl 80 WP(Topstar) 45 g/acre

Apply within 0-3 days after crop sowing. If sown in vattar condition, apply as soon as possible after sowing. If sowing in dry followed by irrigation/rain, then apply 2-3 days after irrigation/rain.

Chemical control in direct seeded rice

(see Annex 4 for full details)

For mixed weed flora:

– Bispyribac (Nominee Gold, Adora or Taarak) 80 ml/acre
– Penoxsulam (Assert or Granite): Assert (400 ml/acre) or granite (38 ml/acre). Assert formulation is best for post-emergence.
– Bispyribac (Nominee Gold, Adora or Taarak) + pyrazosulfuron (Sathi) 80 ml + 80 g/acre
– Penoxsulam + cyhalofop (Vivaya): 900 ml/acre
– Bispyribac + 2,4-D (80 ml + 250 ml/acre)
– Fenoxaprop with safener (Ricestar)+ ethoxysulfuron (Sunrice) 350-500 ml + 48 g/acre

Note:

1. Time of application: 15-25 DAS (2-4 leaf stage of weeds)
2. Method: Spray using 120-150 lt water for one acre (8-10 tanks/acre) using flat fan or cut nozzle

One need base hand weeding to remove escaped weeds

51

Rice Herbicides

Herbicide	Strength	Weakness
Bispyribac	Broad-spectrum weed control of grasses, broadleaves and annual sedges. Excellent control of *Echinochloa* species	Poor on following grasses *Leptochloa chinensis, Dactyloctenium aegyptium, Eleusine indica, Ergrostis* species.
Penoxsulam	Broad-spectrum weed control of grasses, broadleaves and annual sedges	Poor control of grasses other than Echinochloa, including *L. chinensis, D. aegyptium, Eleusine indica, Ergrostis sp*
Fenoxaprop	Excellent control of annual grassy weeds including *L. chinensis, D. aegyptium, E. indica, Ergrostis* spp	Does not control broadleaves and sedges.
2, 4-D, Almix, Ethoxysulfuron, Carfentrazone	Does not control grass weeds. These need to be mixed with some grass herbicides such as Bispyribac or fenoxaprop or penoxsulam for control of mixed flora	Effective on broadleaf and annual sedges. Also suppresses *Cyperus rotundus*

52

Herbicides

Herbicide	Strength	Weakness
Bispyribac + pyrazosulfuron	Broad-spectrum weed control of grasses, broadleaves and annual sedges. Excellent control of *Echinochloa* species, most of broadleaf and *C. roundus*	Poor on following grasses *Leptochloa chinensis, Dactyloctenium aegyptium, Eleusine indica, Ergrostis* species
Penoxsulam + cyahalofop (Pre-mix)	Broad-spectrum weed control of grasses, broadleaves and annual sedges. Excellent control of *Echinochloa* species, and other aerobic grass weeds such as Leptochloa chinensis and most of broadleaf and annual sedges	Suppresses *C. rotundus and Dactylectenium aeguptium*
Fenoxaprop + ethoxysulfuron	Broad-spectrum weed control of grasses, broadleaves and annual sedges.	Suppresses C. rotundus
Pretilachlor with safener & Oxadiargyl & Butachlor	Broad-spectrum weed control of grasses, broadleaves and annual sedges	Sufficient soil moisture is needed for its activity

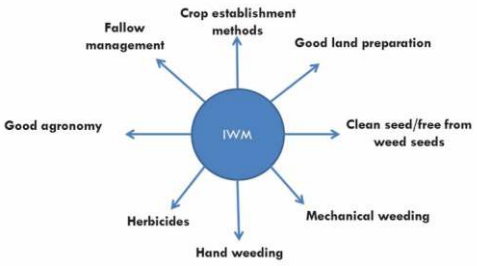
53

Weedy Rice: Emerging Problem in DSR

- Stale seedbed
- Rotating DSR with transplanted rice (manual or mechanical)
- Roughing/cutting panicle by hand

54

IWM Strategies



If we use only one method, weeds get adapted to that method and become resistant/tolerant. Therefore, IWM is key for sustainable weed management

Field Visit for Hands-on Experience

- See full instructions for this exercise in training module Session 3 (Step 3 & 4)

Session IV

Improved Herbicide Spraying Techniques and Handling

PART 1

57

Start with Group Discussion (50 minutes)

- Divide participants into 3 groups
- Ask each group to discuss and write down their notes on flip charts on following points:
  - How herbicides are applied in your area (method)?
  - Do farmers spray themselves or hire labor or service providers for spraying in your area? What % farmers hire for spraying?
  - What types of sprayers used and available in your area?
  - Are you familiar with different types of nozzles and multiple nozzle booms?
  - Do farmers take safety precautions while pesticide handling and spraying- yes or no?
    - If yes to previous Q then list what safety precautions are taken
  - Do applicator calibrate sprayer prior to application?
  - Are different types of nozzle, booms, battery operated spray pump available in your area?

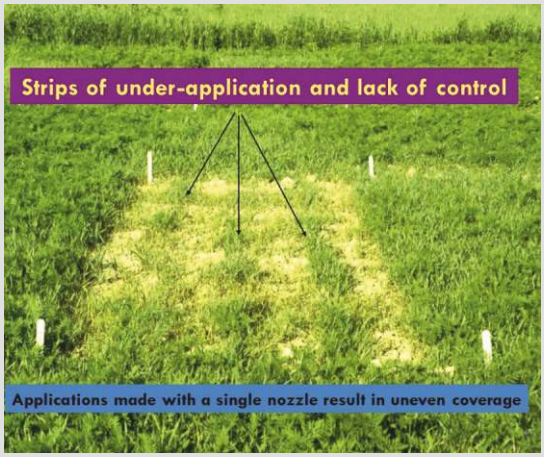
20 minutes for discussion
30 minutes for presentation (10 minutes presentation by each group)

58

Current Application Method

- Single nozzle boom
- Cut or cone type nozzle
- Swinging of boom
- No safety precautions

59



Types of Sprayers

- Knapsack sprayers
  - Hand operated
  - Battery operated
  - Power sprayer

- Mounted sprayers with multiple nozzle booms
  - Tractor mounted
  - Trolley mounted

Note:
- Knapsack are most common for small farmers, therefore focus is on improving herbicide application using knapsack sprayer
- Power sprayers are not recommended for herbicide application

61

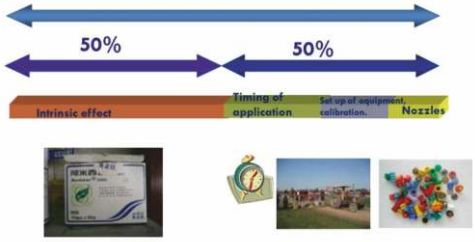
Why is Accurate Application Needed?

- To avoid crop injury
- To maximize herbicide efficacy

62

Efficacy of the Product

Product : Biological results



63

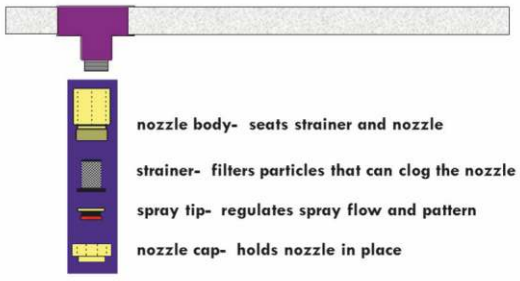
Key Components of Accurate Spray Applications

1. Nozzles
2. Multiple nozzle booms
3. Height of boom
4. Pressure regulation
5. Sprayer calibration

64

Nozzles

Nozzle Assembly



nozzle body- seats strainer and nozzle

strainer- filters particles that can clog the nozzle

spray tip- regulates spray flow and pattern

nozzle cap- holds nozzle in place

66

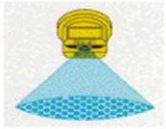
Characteristics of Different Spray Tips

67

Hollow Cone

- not for herbicides
- produce finer droplets
- spray is concentrate on the outside edge of the spray pattern
- spray penetrates better into the plant foliage
- suited for insecticides and fungicides

Flat Fan



- tapered pattern
- produce medium size droplets
- provides uniform application when overlapped with the same nozzle type
- best choice for herbicide applications made with multiple nozzle booms

Flood (cut) tip

- pattern tends to be heavy toward edges
- coarse spray pattern with large droplets
- wide spray swath at low pressure
- less drift
- suited for herbicide application if using single nozzle boom

68

Knapsack Sprayers and Nozzle Choice

Product type	Nozzle choice
Herbicide	Flat fan: Pre & post-emergence or Flood (cut): only pre-emergence and for single nozzle boom
Fungicide	Flat Fan nozzle or Hollow cone nozzle
Insecticide	Hollow cone nozzle or Flat Fan nozzle

69

More evenly distributed droplets with flat fan tips result in greater control with same herbicides.

70

Multiple Nozzle Boom

71

Booms More Efficient than Nozzle Swinging

For insecticides and fungicides in field crops: swinging of the lance is acceptable but care must be taken to ensure that a regular spray pattern is achieved.

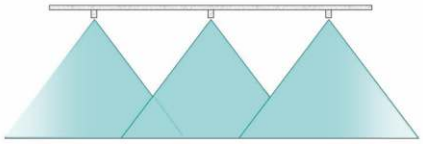
Much more uniform coverage is obtained from using a boom sprayer than a single nozzle lance with a swinging movement

A Syngenta study in Vietnam showed that a swinging nozzle put 64% of the application volume on the target compared with 98% from a boom sprayer.

72

Multiple nozzle booms increase accuracy, uniformity and efficiency

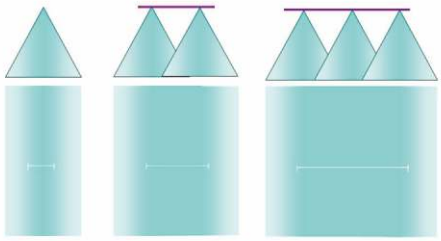
Using Flat Fan Nozzles on a Multi-nozzle Boom



Adjust spray height in the field to overlap 30% of each nozzle's spray pattern. This is true for all flat fan nozzle angles and sizes.

74

Flat fan spray pattern and effective spray swath using one, two and three nozzle booms



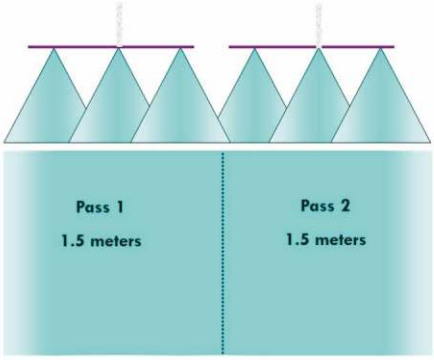
75

To determine the spray swath of a multiple nozzle boom, multiply the nozzle spacing by the number of nozzles. This will equal the spray width per pass.

For Example:
A three nozzle boom with nozzles spaced 50 cm apart will have a spray width of 150 cm.
(50 cm spacing x 3 nozzles = 150 cm spray swath)

A four nozzle boom with nozzles spaced 50 cm apart will have a spray width of 200 cm.
(50 cm spacing x 4 nozzles = 200 cm spray swath)

76



Flat fan spray pattern with two passes of a three nozzle boom having a 3 meter spray swath

77

Tractor Mounted Sprayer

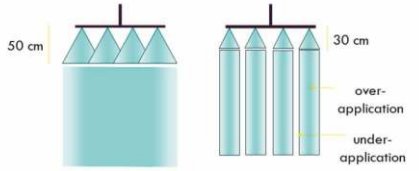
Battery Operated Multi-nozzle Spray

Uniform spray, safe application (applicator not directly exposed), better efficacy

79

Boom Height

Sprayer height needs to be correct in order to obtain the desired spray pattern



Proper boom height with good spray distribution

Improper boom height resulting in no nozzle overlap and poor coverage

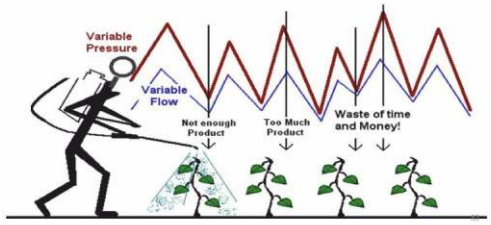
81

Sprayer Pressure

Pressure

- Pressure control sprayer output and size of droplets
- Variable pressure will cause variable output

Sprayer output may vary as you pump, reducing the ability to apply an even application rate.

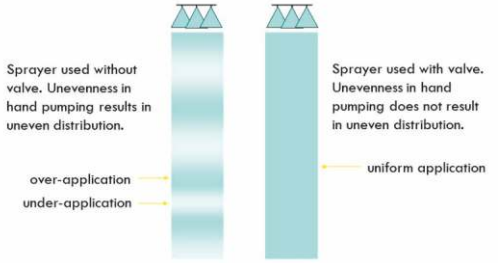


Pressure Regulation: Use of Constant Flow Valve

- Sprayer pressure can be stabalised and controlled using constant flow [CF] valves.
- CF valves are available to operate at 1, 1.5, 2 and 3 bar pressures. (1 bar= 14.5 psi)
- Benefits
  - Uniform application.
  - Less pumping effort whilst spraying.
  - Can save product.
  - Increases reliability of product performance
  - Reduces spray drift

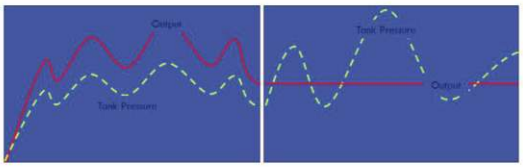
84

Potential Spray Distribution With and Without Regulator Valves



85

Sprayer output without regulator valve / Sprayer output with regulator valve



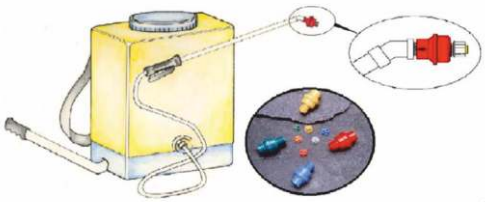
Output changes with pressure

Pressure at the nozzle and output remain constant even while tank pressure changes

86

Constant Flow Valve Placement

For the most accurate pressure fit CF valve close to the nozzle.



87

Session IV

Spray Calibration, Herbicide Mixing/Handling, Spray Drift, Safety & Storage

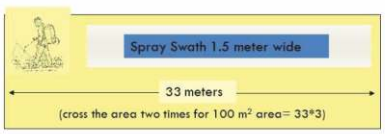
Part 2

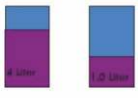
88

Sprayer calibration

- **Calibration is simply determining the sprayer output for a known area.**
- **The factors that influence sprayer output are:**
  - **speed,**
  - **nozzle capacity**
  - **pressure**

Calculation for Water Volume





Initial volume in spray tank

End volume in spray tank

Calibration: Used 3.0 Liters to cover 100 square meters or 1/100th of a hectare. Multiply 3.0 Liter by 100 to find 300 L/ha sprayer output.

90

Calculation of Herbicide Per Tank

1. Spray volume= 300 lt/ha or 120 lt/Acre
2. Volume of one tank = 15 lt
3. Recommended dose of X herbicide (product based) = 250 gm/ha or 100 g/Acre
4. No. of tanks/acre needed = 120/15= 8 tanks/Acre
5. Put 100 gm of herbicide in 8 L of water for 1 Acre and mix it well
6. Take one lt of this stock solution and add in 1 tank of 15 lt capacity and mix it well

91

Calculation for those pesticides & herbicides recommended on volume basis (% solution)

1. For example recommended rate of pre-seeding herbicide like glyphosate is = 1% of spray solution
2. It means 1 liter (1000 ml) per 100 litre of water i.e. 10 ml per liter of water
3. Herbicide per tank of capacity 15 litre = 10*15 =150 ml/tank

Calculation of surfactant per tank

1. For example recommended rate of non-ionic surfactant is = 0.2% of spray solution
2. It means 0.2 lt (200 ml) per 100 litre of water ≃ 2 ml per lt water
3. Surfactant needed per tank of capacity 15 litre = 30 ml/tank

92

Hood/Shield

93

Questions for Participants (10 minutes)

- During sprayer calibration, 4.5 liter water was consumed covering 100 m^2 area. What would be the sprayer output (amount of water) per ha?
- How many tanks will be needed to spray 1 ha area if tank capacity is 15 liters?
- If it is recommended to use surfactant @ 0.25% by volume, how much surfactant per tank is needed if a spray tank is of 15 liter capacity?

94

Other Important Points

1. Proper Mixing of Chemicals

- Chemicals must be well mixed when first put into the tank (fill tank half with water then add herbicide and then fill tank to full and stir well to mix)
- Stop at intervals while spraying to keep the spray mixed (for shaking the tank)
- Never allow too much time between mixing and spraying [herbicide can settle at bottom especially if herbicide formulation is powder form. Therefore, mix well again just prior to spraying]

96

Pesticide Handling and Safety

Wash off any chemical product immediately

Do not eat, drink or smoke when handling chemicals

Do not leave products unattended and within reach of children or animals

Clean all equipment after use and return unused product to the locked store

Always wash after working with chemicals, taking great care not to contaminate any drinking water sources

97

2. Surfactants

Surfactants may be used with herbicides to help them bind to, penetrate or spread uniformly over leaf surfaces.

Use Clean Water for Spraying

- Muddy/dirty water can reduce the herbicide efficacy as soil clay particles can bind herbicides, so always use clean water instead of running channel water
- This will also reduce the risk of nozzle clogging

100

3. Cleaning of Tank After Spray

Clean the sprayer after use or when changing to a new chemical

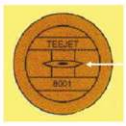
1. Rinse the tank with clean water
2. Add fresh water and spray it through the wand or boom
3. Repeat

With most herbicides extra precaution should be taken to ensure that no chemical is left in the sprayer

101

4. Cleaning Clogged Nozzles

Nozzles may occasionally become clogged or partially clogged.
Care should be used in cleaning nozzles.
Improper cleaning may damage the nozzle.



Never clean nozzle hole with a wire or any other hard narrow tool

Clean by removing the nozzle from the boom or lance and rinsing it in water. If necessary, a soft brush can be used.

5. Strainers

Keep debris from clogging the nozzle

With sprayers being filled from irrigation ditches, ponds, and other unfiltered water sources, strainers are essential to maintain the proper function of spray tips

103

6. Avoid spray drift

Causes of Spray Drift

- Spray Tip Height- Greater spray heights increase the chance that wind can move small droplets off target.
- Wind- Drift potential increases as wind speed increases. Larger nozzles and lower spray pressures should be used as wind speed increases.
- Droplet Size- Small droplets are more susceptible to drift. Small nozzles and high pressure form small droplets.

104

Avoid Spray Drift

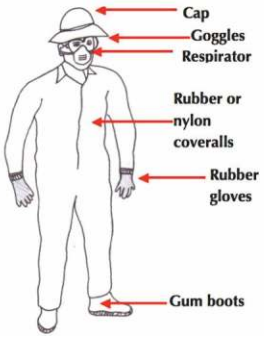
105

7. Pesticide Safety

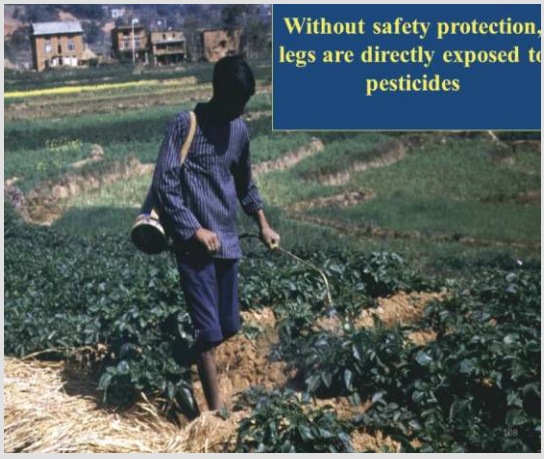
- wear boots, long trousers and rubber gloves when spraying
- keep all pesticides out of eyes and mouth
- avoid contact with the skin
- wash with soap and water if contact occurs
- do not eat, drink or smoke while handling pesticides
- change and wash clothing after spraying
- do not reuse empty pesticide containers

106

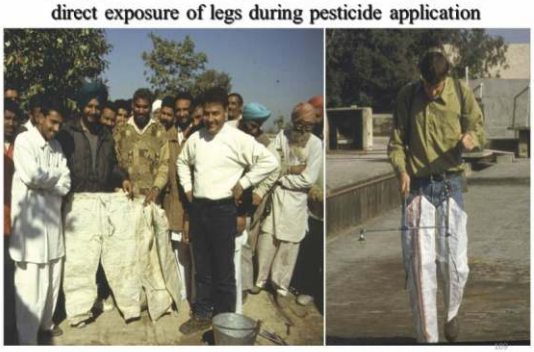
Wear the Correct Protective Clothing



107



Safety pants made from plastic fertilizer bags prevent direct exposure of legs during pesticide application



CALIBRATION: HANDS-ON EXERCISE (PRACTICAL) [90 MINUTES]

Session V

Review/key take-home messages, Q&A, Post-evaluation test and Closing

Review: Session II

- Name three categories of weeds
- How will you differentiate grasses from sedges?
- Is *Echinochloa crus-galli* a grass or broadleaf or sedge?
- Is *Cyperus rotundus* a grass or broadleaf or sedge?
- How will you differentiate *Echinochloa* from other grasses?

Review: Session III

- Why weeds are more problematic in DSR than transplanted rice?
- List different methods of weed control
- Why integrated weed management is needed?
- What are emerging weed species in DSR systems?
- What is stale seedbed technique?
- What is dust mulching?
- Classify types of herbicides based on their time of application
- Name 1-2 pre-emergence herbicides recommended for
  - DSR
  - Transplanted rice
- Name post-emergence herbicides recommended for rice

Review: Session IV

- Which type of nozzles are recommended for herbicide application?
- Single nozzle boom versus multiple nozzle boom - which will give uniform application?
- Is swinging the boom right method? Why?
- What should be boom height while spraying from target?
- Which sprayer will spray with uniform pressure (manual operated or battery operated)?
- Why is it important to use clean water for spraying?
- What is sprayer calibration? Why is it important?
- Why and how the spray tank should be cleaned after use?
- Is it advisable to spray on a windy day? What are the risks?
- Why to wear protective clothing when mixing, spraying, and disposing of herbicides?
- What items are included in protective clothing?
- Why proper mixing of herbicide is important?
- Why herbicide bottles/containers should not be used for any other purpose than holding herbicides?

ANNEX 4: HERBICIDE OPTIONS FOR RICE

A) Transplanted rice

Sr. No.	Herbicide name	Product name	Dose (ai/ha)	Product dose (ml or g/ha)	Weed control	Time and method of application
PRE-EMERGENCE						
1	Butachlor 50EC	Machete	1250 to 1500	2500 to 3000	Grasses, broadleaf and annual sedges	Spray using 375 lt/ha water volume or mix the chemical in 150 kg sand/ha and broadcast uniformly in standing water of 4-5 cm depth 2-3 days after transplanting.
2	Pretilachlor 50 EC	Rifit, Eraze	750	1500	Grasses, broadleaf and annual sedges	
POST-EMERGENCE						
3	Bispyribac-sodium 10 SL	Nominee-Gold, Adora. Taarak	20-25	200-250	Grasses, broadleaf and sedges. Very effective on Echinochloa spp. But weak on these grasses: Leptochloachinensis and Dactylocteniumaegyptium. Effective on annual sedges but suppresses perennial sedge (Cyperus-nutsedge).	Spray 15-25 DAT using 300 liter water/ha when weeds are 2-5 leaf stage.
4	Penoxsulam 2.5OD Or Penoxsulam 24 SC	Assert Granite	22.5-25	Assert: 100 Granite: 95	Grasses, broadleaf and sedges. Weak on aerobic grasses such as Leptochloa chinensis. Good on many aquatic weeds. Assert formulation is more effective as post-emergence at 3-5 leaf stage of weeds. Granite is effective as early post-emergence when weeds are 1-3 leaf stage.	
5	Penoxsulam + Cyhalofop-butype (Pre-mix)	Vivaya	135	2250	Grasses, broadleaf and sedges. It is also effective on aerobic grass weeds such as Leptochloa chinensis.	
6	Bispyribac 10 SL + pyrazosulfuron 10 WP	Nominee Gold/Adora/ Taarak+Sathi	20+20	200+200	Grasses, broadleaf and sedge. Use this mixture if weed flora is complex and dominated by Cyperus rotundus.	
7	Fenoxaprop-p-ethyl 6.9EC+ ethoxysulfuron 15WG (Tank mix)	Ricestar + sunrice	60+18	875+120	All major grasses (Echnochloa and other aerobic grass weeds such as Leptochloa chinensis and Dactylectenium aegyptium), broadleaf weeds and sedges.	
8	Metsulfuron + chlorimuron 20 WP	Almix	4 (2+2)	20	Broadleaf and sedges	
9	2,4-D ester 38 EC	Almix	500	1315 (if 2,4-D ester 38 EC) or 625 ml (if 2,4-D sodium salt 80%)	Broadleaf and suppresses sedges	
10	Ethoxysulfuron 15 WDG	Sunrice	18	120	Broadleaf and sedges	

B) Direct seeded rice

Sr. No.	Herbicide common name	Product name	Dose (g ai/ha)	Product dose (ml/ha)	Weed control	Time and method of application
PRE-EMERGENCE						
1	Pendimethalin* 30 EC	Stomp	1000	3333	Grasses, broadleaf and sedges	Apply on the same day of sowing under vattar condition. If sown in dry and irrigated, apply 1-3 days after seeding using 375-500 lt/ha water volume. Good soil moisture is important for better efficacy.
2	Pretilachlor with safener 30.7EC	SOFIT or ERAZE-N	500	1629	Grasses, broadleaf and sedges	
3	Oxadiargyl 80 WP	Topstar	90	112.5	Grasses, broadleaf and sedges	
POST-EMERGENCE						
4	Bispyribac-sodium 10 SL	Nominee Gold,Adora/ Taarak	25	250	Control grasses, broadleaf and sedges. Very effective on Echinochloa species and Ischaemumrugosumbut poor on Leptochloa chinensis & Dactyloctenium aegyptium.	Spray 15-25 days after sowing using 300 liter water/ha when weeds are 2-5 leaf stage.
5	Penoxsulam 2.5OD Or Penoxsulam 24 SC	Assert Granite	22.5-25	Assert: 100 Granite: 95	Grasses, broadleaf and sedges Weak on aerobic grasses such as Leptochloa chinensis. Good on many aquatic weeds. Assert formulation is more effective as post-emergenceat 3-5 leaf stage of weeds. Granite is effective as early post-emergence when weeds are 1-3 leaf stage	
6	Penoxsulam + Cyhalofop-butype (Pre-mix)	Vivaya	135	2250	Grasses, broadleaf and sedges. It is also effective on aerobic grass weeds such as Leptochloa chinensis.	
7	Bispyribac-sodium + pyrazosulfuron	Nominee Gold/Adora /Taarak + Sathi	25+20	250+200	For complex weeds flora and control grasses, broadleaf and sedge. Use if complex weed flora dominated by Cyperusrotundus.	
8	Fenoxaprop-ethyl with safener + ethoxysulfuron	Ricestar + Sunrice	90+18	1300+120	For complex weeds flora and control grasses, broadleaf and sedge. This is effective on emerging DSR weeds like Leptochloa and Dactyloctenium.	

*Pendimethalin could be phytotoxic and may reduce germination, if it comes in direct contact of seeds. In dry sowing, apply after seeds have imbibed (at least 24 or 48 hr after irrigation or rain)

The Cereal Systems Initiative for South Asia (CSISA) is a regional initiative to sustainably increase the productivity of cereal-based cropping systems, thus improving food security and farmers' livelihoods in Bangladesh, India and Nepal. CSISA works with public and private partners to support the widespread adoption of resource-conserving and climate-resilient farming technologies and practices.

International Maize and Wheat Improvement Center (CIMMYT)
Km. 45, Carretera. México-Veracruz, El Batán, Texcoco CP 56237.
Edo. de México . Mexico.
www.cimmyt.org

International Rice Research Institute (IRRI)
DAPO Box 7777, Metro Manila 1301, Philippines.
www.irri.org

International Food Policy Research Institute (IFPRI)
1201 Eye St, NW
Washington, DC 20005 USA
www.ifpri.org