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9. ABSTRACT

Although much has been added to the knowledge of increasing rice yields in recent years, the flow of information to the rice farmer has been slow. This manual is intended for extension workers involved in teaching the new rice technology. The manual contains all the lessons on the skills of producing rice. The subjects discussed, in detail and with illustrations, are: land preparation, production of seedlings, preparation for planting, fertilizers, agricultural chemicals, weed control, insect control, disease control, and harvesting and processing of grain.

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TRAINING MANUAL FOR RICE PRODUCTION

VO-TONG XUAN and VERNON E. ROSS

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TRAINING MANUAL FOR RICE PRODUCTION

VO-TONG XUAN and VERNON E. ROSS

ILLUSTRATIONS by FEDERICO GATMAITAN, JR.
(except chapter 7 and chapter 9, lesson 5)

THE INTERNATIONAL RICE RESEARCH INSTITUTE 1976

"The more I study this subject, the more I am convinced that both basic and applied research on rice is some years ahead of its application in the field and that this gap between knowledge and its application is widening. If only the more simple cultivation methods recommended were put into practice, methods that are not beyond the capacity of the peasant farmer, the increase in world rice production would be startling."

D. H. Grist

FOREWORD

In recent years rice researchers have added greatly to the storehouse of knowledge on how to increase rice yields. Unfortunately, the flow of this new knowledge to the rice farmer has been slow. The need exists to train rice extension workers in this new technology so they in turn can teach farmers. This manual has been developed to serve those involved in teaching the new rice technology. In addition, it can serve scientists and farmers alike, as a reliable guide to the performance of the tasks involved in producing irrigated rice.

The manual contains all the lessons on the skills of producing rice. The authors have made liberal use of "Preparing Instructional Objectives" by Dr. Robert F. Mager and "The Preparation of Occupational Instructors," a suggested course guide published by the U.S. Department of Health, Education, and Welfare, Office of Education. The technical information is based on reports and writings of IRRI scientists, technical publications of private businesses, and many other sources.

— *Vernon E. Ross*

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1. LAND PREPARATION

1. PLOWING AND HARROWING WITH A CARABAO (WATER BUFFALO)

Objectives: To be able to handle a carabao in an irrigated or rainfed field in breaking up the soil at a given depth with a moldboard plow and to pulverize and level correctly with a harrow; to mix mud and water thoroughly to allow weeds, rice straw, and stubble which have been turned under to decay thoroughly.

Materials: Each group of trainees will need:

1 carabao
1 moldboard plow (Fig. 1)
1 harrow (Fig. 2)

Each trainee will need:

3 blank sheets of work schedule (Fig. 3)

Teaching aids: Slides showing steps involved in plowing and harrowing
Transparencies for overhead projector showing the direction of movement of the plow and the harrow

INTRODUCTION

Lowland rice requires well-puddled, well-prepared soil to:

1) Provide a soil surface that is weed-free, soft, and level to make transplanting easier.
2) Mix organic matter (rice straw, stubble, and weeds) with the soil and encourage decomposition.
3) Level the field for uniform distribution of irrigation water, fertilizers, and pesticides.
4) Prevent or minimize water seepage from the field.

If land preparation is not uniform, the rice plants will grow unevenly causing differences in plant development and stage of maturity from one part of the field to another. Weeds, insects, and other pests are likely to be worse. If organic matter is not well decomposed by the time of transplanting, the seedlings are likely to suffer from toxic substances given off during decomposition. For these reasons, land preparation should be started at least 2 weeks before planting.

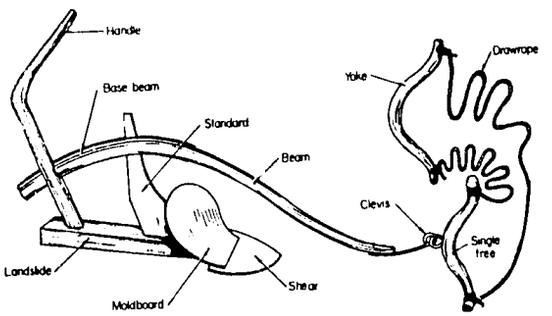


Fig. 1. A moldboard plow.

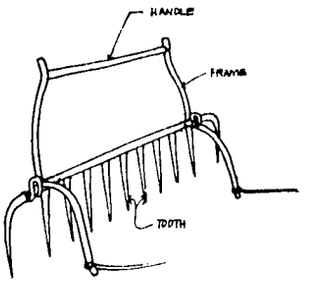


Fig. 2. A harrow.

TENTATIVE WORK SCHEDULE

DATE	DAY	ACTIVITIES: PLANNED ACTIVITIES	ACTUAL ACCOMPLISHMENTS	REMARKS

Fig. 3. Sample of a work schedule sheet.

PRESENTATION

Land preparation consists of two operations: plowing and harrowing.

Operation 1. *Plowing*

Steps	Key points
1 Get the field ready for plowing	a) Remove from the field anything that may injure the plowman such as weeds with thorns. b) Cut tall growth or stubble that will interfere with plowing. c) Flood the field 2 to 7 days before plowing depending on the hardness of the soil. Keep the surface of the soil just covered with water; this will help keep the soil from sticking to the plow.
2 Get the plow and carabao ready for plowing	a) Hitch the carabao to the plow by putting the yoke around its neck. Secure the yoke in place with a leather belt. See Fig. 4. b) Always approach the carabao from the side to avoid its sharp horns.
3 Start plowing	a) Begin plowing near the levee. First plow in a clockwise direction to move the soil away from base of levee. This will facilitate subsequent repair of levees. Then for the rest of the field, move the soil to the outside edge by plowing in a counterclockwise direction. b) Plow to a depth of at least 15 cm; deeper if necessary to incorporate and cover organic matter better. *To adjust the depth of cut:* — Push the handle to plow deeper; — Pull the handle to plow shallower; too much pulling force may lift the whole moldboard assembly out of the soil. *To turn left or right at a corner:* — Lift the plow up completely and let it move freely on its landslide. With a combined pushing-lifting force, guide the handle toward the *left* if you want to turn right, and vice versa. *To keep the furrow straight:* — When moldboard is moving out of a straight line and toward the right, push the handle sideways to the *right* until a straight furrow is being cut; and vice versa.
4 Flood the field	Keep the soil flooded with about 1 cm of water until harrowing, a duration of about 7 days if possible. This provides time to soften the soil clods further and allows the weeds to sprout, while plowed fresh organic materials undergo decomposition.

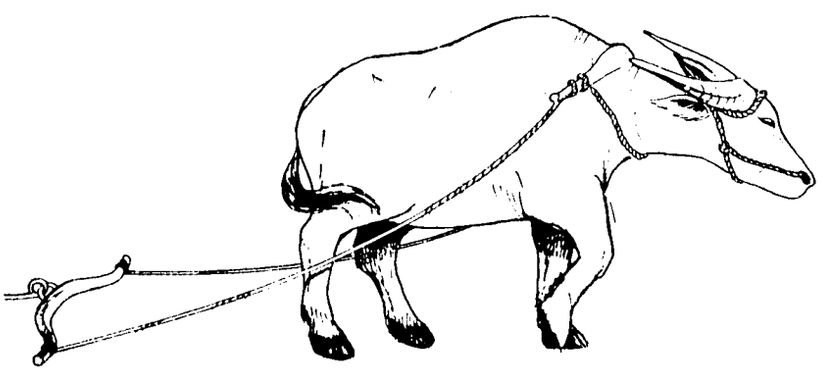


Fig. 4. Hitching the plow to the carabao.

Operation 2. *Harrowing*

Steps	Key points
1 Drain off excess water	Leave just enough water to show the high and low spots.
2 Get the harrow and carabao ready for harrowing	See Step 2 — PLOWING and Fig. 5
3 Harrow	a) Start from the edge of the field and work parallel to the edge, lengthwise. b) Then harrow the field crosswise. c) Then harrow the field lengthwise again. During this pass, place the harrow so its teeth are between the tracks made by the teeth in the first lengthwise pass. Two lengthwise harrowings and one crosswise harrowing are usually sufficient to puddle the soil adequately. d) Scrape mud from high spots and move it to low spots. To do this, pull the handle of the harrow backward, so that mud is pushed by the base of harrow teeth; unload the mud at low spots by pushing the handle of the harrow forward. e) The prepared land may be well levelled with a bamboo pole or wood plank attached to the base of harrow teeth during the last pass of the last harrowing. When necessary, the whole harrow assembly may be replaced by a wood plank of convenient length.
4 Flood the field	Keep enough water in the field to prevent the soil from drying and hardening. If possible, wait for 7 to 10 days between two successive harrowings to allow more weed seeds to germinate before they are finally turned under the soil and to give more time for plowed fresh organic matter to decompose.

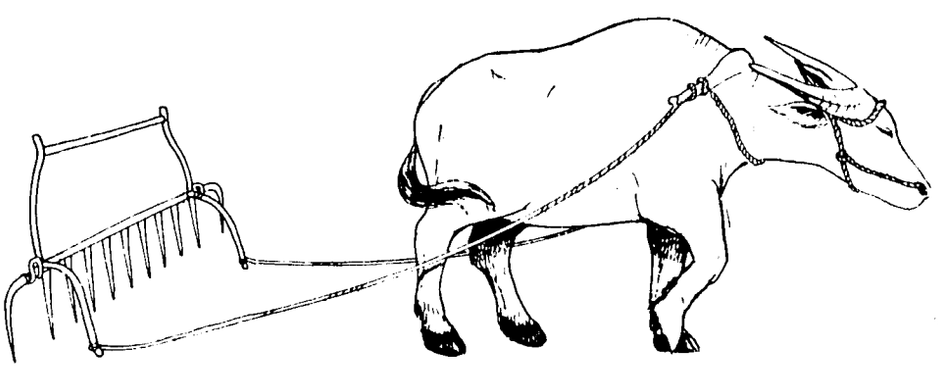


Fig. 5. Hitching the harrow to the carabao.

Land preparation in rainfed flooded fields

Farmers in many rice growing areas do not have irrigation facilities. Their crops depend entirely on the availability of rains. One major problem facing these farmers is timing of field operations, especially raising seedlings so that plants will be available when the field is ready for transplanting.

Steps	Key points
1 Get the field ready	a) Remove from the field anything that may injure the plowman, such as weeds with thorns. b) Cut tall growth or stubble that will interfere with plowing. c) Repeat this operation if necessary while waiting for the first rains.
2 Plow	Soon after the first heavy rains, start plowing as presented in Steps 2 & 3 — PLOWING.
3 Replow	If the first plowing was not thorough, replow after the next heavy rain.
4 Harrow	Harrow the plowed field as in Operation 2 — HARROWING after the next heavy rain.

Characteristics of a well prepared lowland ricefield

Usually, one plowing and three harrowings 1 week apart are sufficient to get ready for transplanting. The field by then should have the following characteristics:

a) Mud and water are thoroughly mixed;
b) Weeds, rice straw, and stubble, which have been plowed under, are thoroughly decayed; and
c) Land is well levelled.

APPLICATION

A. Schedule of land preparation

If you plan to transplant 21-day-old seedlings, when is the latest time you can start preparing the land? Base your answer on the *day of sowing* the seed on wetbed. Distribute the blank sheets of work schedule to each trainee and do an example to answer the above question.

B. Have each trainee plow one straight furrow in an assigned area and make one pass with the harrow.

EVALUATION

1) How many days before plowing must the field be flooded? Why?
2) Why must the field be flooded before plowing?
3) Why should plowing be started next to the levees in a clockwise direction?
4) Why do you flood the soil after plowing or after each harrowing, and wait for 7 days before the next harrowing?
5) Why is it better to harrow when only a few centimeters of water are in the field?
6) Describe the characteristics of a well-prepared lowland ricefield.
7) From a biochemical point of view, why should land preparation be started at least 2 weeks before transplanting?
8) What are the precautions in handling a carabao?
9) What is the most difficult problem facing farmers in rainfed areas?

2. CONSTRUCTION AND REPAIR OF LEVEES

Objective: To be able to construct and repair levees properly to minimize water losses through seepage.

Materials: 1 scythe for each trainee
1 shovel or large knife (bolo) for each group of trainees

Teaching aids: Slides showing the steps involved in the construction and repair of levees

INTRODUCTION

Before preparing the land, levees (dikes or bunds) should be repaired to help reduce seepage from the paddy. Paddies that are properly repaired and plastered with mud are unfavorable to rats and make it difficult for weeds and host plants of insects to get established.

PRESENTATION

The best time to fix levees is after the first plowing because the upturned soil near the levees can be used in the work. Levees should be repaired before harrowing so the weeds cut from the levees can be incorporated in the soil well before the rice is planted.

Steps	Key points
1 Clean the levee	a) On the top and both sides of the levee cut the weeds close to the roots using a scythe, a knife, or a shovel. This will also trim off thick portions of the levee. b) Remove any straw, twigs, leaves, etc. c) Pay attention to rat holes, breaks, and soft spots in the levee.
2 Repair the levee	a) Destroy all rats by placing cyanide dust (potassium cyanide) in their holes, or break up and rebuild the portion of the levee containing rat holes. b) Use soil that has been broken up by the first plowing for patching soft spots and cracks.
3 Plaster the levee	a) Use additional mud and water, if necessary, to smooth levee with hands. b) Give special attention to the sides to make sure that all cracks are sealed properly. Otherwise water in the plot may seep to other plots.

APPLICATION

The trainees will construct and repair levees around the plot where they practiced plowing previously.

TEST

1) Why should you have clean levees?
2) Why should you have well plastered levees?
3) Why is it necessary to repair levees after plowing but before harrowing?

2. PRODUCTION OF SEEDLINGS

1. BREAKING THE DORMANCY OF SEED BY THE NITRIC ACID METHOD

Objective: To be able to hasten the germination of seeds by using a solution of nitric acid to break seed dormancy.

Materials: Each group of trainees will need:

6.3 ml concentrated nitric acid (69% HNO_3) for every liter of water
1 plastic or glass container, 2-liter capacity
500 g newly harvested seed
1 bamboo or wood stirrer
1 graduated glass cylinder, 10-ml capacity, or any available noncorrosive liquid measuring container
1 weighing scale, capacity not less than 1 kg
1 glass jar, 150 ml capacity

Teaching aids: Slides showing the steps involved in the nitric acid method of breaking seed dormancy

INTRODUCTION

Mature seeds must go through a rest period (dormancy) before they will germinate. Seeds of traditional tropical rice varieties often will not germinate immediately after harvest and have a long period of dormancy. This is a valuable characteristic in tropical rice areas where rain and high humidity frequently occur during the harvest period. But when the farmer wants to grow the same variety the year round and depends on the preceding crop as a source of seed, dormancy longer than 2 to 3 weeks can be a real disadvantage. Therefore he must be able to break the dormancy of seed. Seed dormancy is also a problem for the plant breeder who needs to reduce the time interval between crops and the seed analyst who must determine germination capacity. A desirable dormancy period is about 2 to 3 weeks. It is short enough to enable the farmers to use the seeds for the succeeding crop and long enough to prevent the grain from sprouting in the panicle during a rainy and humid harvest season.

PRESENTATION

An effective way to break seed dormancy is to treat the seeds with diluted nitric acid (0.1 *N* HNO_3).

Steps	Key points
1 Prepare the seed	Air dry the seed and clean them to remove unfilled grain, straw, and other foreign matter.
2 Weigh the seed	Record the weight in kilograms to know how much solution to prepare.
3 Compute correct amount of water needed	a) Always use a multiple of 1 liter of water to facilitate liquid measuring. b) *For a small amount of seed*, 1 liter of water is usually best. *For a larger quantity of seed*, use 1 liter of water for every 1 kg of seed.
4 Compute correct volume of concentrated acid to be used	To make a 0.1 *N* solution, 6.3 ml of concentrated nitric acid (purity should not be less than 68%) is needed for every liter of water to be used. $\text{ml of concentrated nitric acid needed} = \frac{6.3 \times 100}{\%\ \text{purity} \times \text{sp. gr. of acid}}$

To derive the above formula:

a) First compute the Normality N of concentrated nitric acid.

$$N = \frac{\text{\% purity x specific gravity of acid x 1,000}}{\text{100 x 63 (milliequivalent weight of nitric acid expressed in grams per 1,000 milliliters)}}$$

b) Compute volume of concentrated nitric acid needed to make 0.1N solution using the equation:

Normality x Volume of desired solution = Normality x Volume of concentrated solution

or

0.1N x 1,000 ml = N in (a) x ml of concentrated nitric acid needed

5 Pour the computed amount of water into a container	a) Use a plastic or a glass container. Do not use a metal container. It may react with the acid thus reducing the desired strength of the acid. b) To treat a large amount of seed, use a cement sink, or other noncorrosive container.
6 Measure the correct volume of concentrated nitric acid	Carefully pour concentrated nitric acid into a completely dried, graduated glass cylinder to the desired volume mark. CAUTION: Concentrated acid spilled on table top, hands, or clothing may cause serious burns. If acid is spilled, flood immediately with water.
7 Mix acid and water	a) Always pour concentrated acid *into* water. CAUTION: If water is poured into concentrated acid there will be an explosion and spattering. b) Stir the solution quickly but thoroughly with a bamboo or wood stirrer.
8 Soak the seed in acid solution	a) Pour clean seeds into the acid solution. b) Remove all floating seed, using cloth net or wooden paddle. c) Soak the seed for 16 to 24 hours, but not longer.
9 Drain off acid solution and dry the seed	a) Place seed in the sun to dry. b) Sun-dry for 3 to 5 days after soaking to storing moisture content (14%).
10 Store dried seed	a) Store seed in dry condition for 5-7 days. This will give 80 percent germination or better.

APPLICATION

1) Assign each group of trainees one variety of seed.
2) Have each trainee work with 100 g of seed:
   a) Break dormancy by nitric acid treatment.
   b) Check seed germination by ragdoll method.
   c) Compare with control sample.
   d) Report results.

EVALUATION

1) Cite an advantage of seed dormancy.
2) When is seed dormancy not desirable?
3) In the nitric acid treatment, what is the ratio of seed to water?
4) Why is it important to specify concentrated nitric acid with purity not less than 68 percent?
5) What are the precautions in using concentrated nitric acid?
6) What is the recommended duration for soaking seeds in nitric acid solution?
7) What is the most desirable dormancy period? Why?

2. TESTING THE VIABILITY OF SEED

Objectives: To be able to perform seed germination tests by using the petri dish, the ragdoll, and the seedbox methods; to determine the percentage of viability of a given stock of seed; and to determine the approximate quantity of seed needed to plant a given area at a given seeding rate.

Materials:

Each trainee will need:
- 4 paper tags for labeling
- 4 pieces of cloth, size 15 x 20 cm
- 12 rubber bands or string
- 4 wooden labeling pegs, size 20 cm (or 8 in)
- 4 bamboo sticks, size 0.5 x 1 x 30 cm

Each group of trainees will need:
- About 10 kg seed
- 1 grease pencil
- A pail of water
- 4 sets (bottom and cover) of petri dishes
- 4 pieces of filter paper, round to fit bottom of petri dish
- 1 box 15 x 30 x 50 cm, filled with soil 10 cm deep

Teaching aids: Slides showing the steps involved in the tests, and the effect of the fume of Eptam on germination

INTRODUCTION

Testing viability is one of the minor tasks in rice production. It deserves more attention, however. Without knowing the percentage of germination, one may not be able to make an intelligent guess of the amount of seed needed to plant a field at a recommended seeding rate. The viability of seed can be determined by three methods. These are the ragdoll, the petri dish, and the seedbox methods. The result of any of these tests indicates whether a stock of seed is suitable for planting and serves as a basis for computing the correct amount of seed to use.

Fig. 1. Example of a label.

PRESENTATION

A. *Testing methods*

The petri dish method

Steps	Key points
1 Obtain composite sample of seed to be tested	a) Take seed at random. b) Discard all unfilled seed. c) Count exactly 100 seed.
2 Label the petri dish cover	Using a grease pencil, indicate variety, date performed, replication, and name of worker (Fig. 1).

3 Place a piece of filter paper in a petri dish	Use only the bottom petri dish.
4 Moisten the filter paper	Add just enough clean water to cover the filter paper. (Too much water will cause the seed to float).
5 Place the seed on the filter paper	a) Evenly distribute all the 100 seeds on the filter paper. Placing too many seed in one place tends to complicate subsequent counting of germinating seeds. b) Do not add water immediately after placing seeds on the filter paper because water drops may displace the seed and group them in clusters.
6 Cover the petri dish	Use the labeled cover.
7 Let the seed germinate	a) Place the whole set of petri dishes in a safe place. b) Room temperature is favorable for germination. Do not place the dishes in an air-conditioned room. c) Maintain enough moisture in the dish to wet the filter paper by occasionally adding drops of water. d) The seed will germinate in 4 to 5 days.
8 Count germinated seed	a) At the end of the germination period, count the seed having shoots and roots. b) All shoots must be longer than 1 cm. If they are not, seed viability may have been damaged. Figure 2 shows germination of normal seed and of seed damaged by the fumes of the herbicide Eptam.
9 Record the result	a) The number of shoots counted is the percentage of viability. b) The result is more reliable if the test is replicated four times.
10 Recommendations	a) To be acceptable for planting seed should have 80 percent germination or more. b) If germination is lower than 80 percent, but above 60 percent, you may have to sow more seed in the seedbed to make up for poor germination. c) If the germination is lower than 60 percent, do not use the seed unless they are the only ones available.

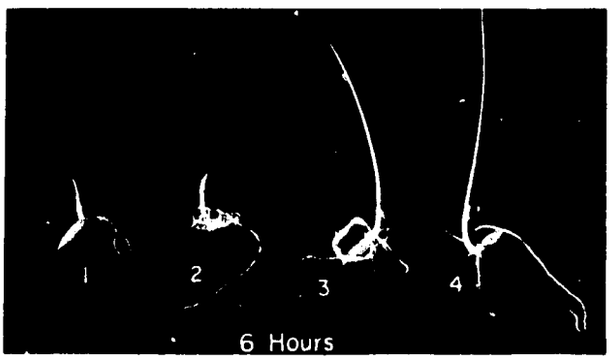


Fig. 2. Effect of the fumes of herbicides on germinating seeds. The seeds were exposed for 6 hours to: (1) EPTC granule (5%), (2) EPTC/MCPA (4.3%/1.75%), and (3) MCPA granule (5%). Seed no. 4 was the control.

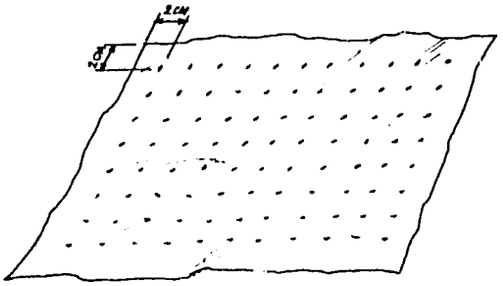


Fig. 3. Position of seed on the ragdoll.

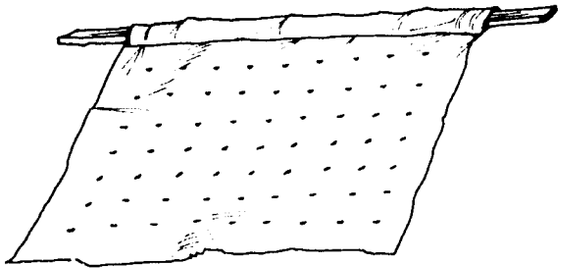


Fig. 4. Bamboo stick on the ragdoll.

Fig. 5. A finished rag doll.

The ragdoll method

Steps	Key points
1 Obtain a composite sample of seed to be tested	a) Take seed at random. b) Discard all unfilled seeds. c) Count exactly 100 seeds.
2 Label the test	Write name of variety, date of test, replication, and name of trainee.
3 Moisten a piece of cloth	a) Soak the cloth in water then squeeze the water out. This helps the seed to stick when placed on the cloth. b) Spread the cloth on a flat surface.
4 Sow the seed on the cloth	a) Distribute all 100 seed evenly in rows of 10. b) Start about 2 cm from each border of the cloth (Fig. 3).
5 Place the bamboo stick on the cloth	Place the bamboo stick along the longer border of the cloth (Fig. 4).
6 Roll the cloth around the stick	a) Press the border of the damp cloth against the stick and simultaneously roll the stick with the cloth while moving toward the opposite border. Do not roll the stick without moving it toward the opposite border or you may disturb your arrangement of seed. b) Secure the cloth in place by tying both ends with rubber bands or string (Fig. 5).
7 Attach label tag to the stick	

8 Let the seed germinate	a) Moisten the seed by dipping the ragdoll in the pail of water, then remove it from the pail. b) About three dippings per day are sufficient to keep the seed continuously moistened. c) Store the ragdoll in a shaded place at room temperature (28°C), but not in an air-conditioned room. d) Protect the ragdoll from rats. e) The seed will germinate in 4 to 5 days.
9 Count the germinated seed	See Step 8 — petri dish method
10 Record the result	See Step 9 — petri dish method
11 Recommendations	See Step 10 — petri dish method

The seedbox method

Steps	Key points
1 Obtain composite sample of seed to be tested	a) Take seed at random. b) Discard all unfilled seed. c) Count exactly 100 seed.
2 Label the seedbox	a) Write name of the variety tested, date performed, replication, and name of worker on a paper tag, or a wooden pot labeling peg. b) Stick the label in the soil at one corner of the seedbox (Fig. 6).
3 Plant the seed in the box	a) Drop seed in rows. One box is sufficient for planting all four replications (Fig. 6). b) Slightly cover the seed with 1.5 cm of soil. c) Water the box after sowing, then occasionally thereafter. Do not let the soil dry. d) Protect the seed from rats. e) The seed will germinate in 4 to 7 days.

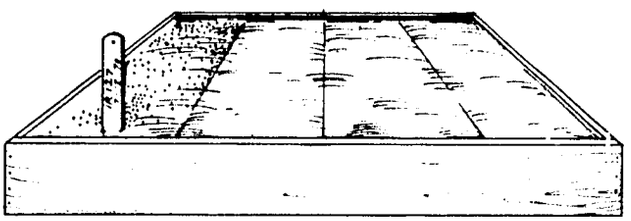


Fig. 6. Seedbox with seed planted and labeled for replication I.

4 Count the germinated seed	a) At the end of the germination period, count the number of shoots above the soil level. b) Do not include in your counting any shoot shorter than 1 cm (See Step 8 — petri dish method).
5 Record the result	See Step 9 — petri dish method
6 Recommendations	See Step 10 — petri dish method

B. *Seed computation*

The approximate amount of seed needed to plant a given area can be estimated when the percentage of germination is known. Suppose the germination of a certain seed stock is 85 percent. If 50 kg of seed are needed to plant a hectare of land, then the required amount of that seed is (assuming the amount of unfilled grain is negligible):

$$\frac{50}{85} \times 100 = 58.7 \text{ kg}$$

APPLICATION

Assign each group of trainees a stock of seed.

1) Have each group test for the viability of the assigned seed by using the petri dish method and the seedbox method, each in four replications.
2) Have each trainee test the viability of the same seed using the ragdoll method.
3) Have each trainee submit a written report on the result of the three tests including the following information:

a) How much of this seed is needed to plant 1,000 sq m if the seeding rate is 44 kg seed/ha.
b) Comparative advantage of each testing method.

EVALUATION

1) Why is it important to know the percentage of germination of a given stock of seed?
2) Why is it undesirable to add too much water to the petri dish?
3) Why do you disregard germinating seed having shoots shorter than 1 cm?
4) Is it advisable to keep the seed in ragdoll dipped in water throughout the period of germination? Why?
5) What is the duration of germination in these tests?
6) Why do you place the seed in room temperature (28°C) during the germination period?
7) Calculate the amount of seed needed to plant 1/4 ha of land given a germination of 75 percent and a seeding rate of 80 kg seed/ha.
8) A stock of seed has 85 percent germination, and an estimated 10 percent unfilled grain. How much of that seed is needed to plant 3.8 hectares at a seeding rate of 50 kg seed/ha?

3. SOAKING AND INCUBATING SEED

Objective: To be able to select good seed; and to induce germination by soaking them in water and incubating them.

Materials:

- 5 kg of seed
- Bucket, 12 liter capacity
- Stirrer, a small wooden paddle
- Water
- 2 wooden pot labels
- 1 pencil
- 1 gunny sack
- Balance

INTRODUCTION

Before germination can take place, the rice seed must be saturated with moisture. Dry seed , if sown directly in seedbed, will germinate slowly because it takes time to absorb sufficient moisture for saturation. On the other hand, seed germinated before sowing will start to grow quickly in the field or seedbed, and will be less affected by diseases, insects, birds, and other pests. Pre-germination consists of soaking and incubating the seed .

PRESENTATION

Operation 1. *Soaking seed*

Steps	Key points
1 Compute the required quantity of seed	Data needed: a) seeding rate: dapog, wetbed, or drybed; b) area to be planted; c) percentage of germination (do not use seed whose germination is less than 6(percent unless they are the only ones available); and d) percentage of unfilled seed. Refer to lessons on "Testing the viability of seed" and "Seed selection by specifi(gravity."
2 Weigh the seed and place them in a container	
3 Add water to the container of seed	Pour water in *slowly* to allow seeds to absorb water evenly and to prevent floating of good dry seed . Gradually raise the water level by pouring in more water until it reaches about 10 cm above the nonfloating seed level.
4 Stir for at least 1 minute and remove unfilled seed	a) Unfilled seed will float on the surface of the water. b) Use hand or strainer to remove and discard unfilled seed.
5 Wash well-filled seed	a) Wash in fresh water. b) Four or five washings are sufficient.

6 Soak the seeds in fresh water	a) Keep water fresh during soaking by changing every 5 to 6 hours. b) Soak seed for 24 hours at normal room temperature (27°C or higher). If temperature is lower, consult the following table.

Average water temperature	*Number of days to soak*
10°C	10
15°	6
22°	3
25°	2
27°	1

7 Label the seed	a) Use wooden pot label. b) Indicate variety and date soaked. c) Leave space in label for date incubated.

Operation 2. *Incubation of soaked seed*
After soaking the seed for 24 hours at room temperature (27°C or higher), proceed as follows:

Steps	Key points
1 Wash the soaked seed	Rinse with fresh water 2 or 3 times, then drain off water.
2 Wet the bag or sack to be used in incubating the seed	a) Soak the bag in water until thoroughly wet. b) Bag should be free from other seed .
3 Place seed in appropriate containers	a) For small quantity of seed, use a cloth bag or gunny sack. In this case, pour the seed in the bag and fold the sack tightly. b) For a larger quantity of seed, a large tray or cement floor can be used. In this case, spread the seed on the floor in a layer 10 to 15 cm deep, and keep it covered with moist sacks.

4 Let the seed germinate	a) Keep the bag in a shaded place. b) Turn the seed occasionally to improve aeration. If the seed are on a cement floor, mix them by hand every 12 hours. Sprinkle water on the seed while mixing. c) Keep the bag moist and keep the seed from becoming too hot throughout the incubation period. On the other hand, if seed are too cold, add warm water to maintain temperature between 20° to 30°C. d) Duration of incubation. (1) For dapog seedbed: 48 hours (A shorter incubation period would result in the seed just opening their coat. Their shoots would just appear, and when they are placed in dapog seedbed they tend to pack too closely. This situation does not promote maximum dapog growth. Allow shoot to grow about 3 to 5 mm long.) (2) For wetbed seedbed: 24 to 36 hours. (A longer duration of incubation will result in longer shoots and radicals, thus making sowing more difficult.)
5 Label the seeds	Use a wooden pot label as in the soaking operation. Add date of incubation.

APPLICATION

Assign each group of trainees an area where they can perform operations 1 and 2 of this task. Check quality of the pregerminated seeds produced by each group according to the key points in Step 4 of operation 2.

EVALUATION

1) Explain the importance of the pre-germination process.
2) Cite four essential data that you should know before soaking seeds.
3) Why should soaking water be kept fresh during soaking period?
4) What is one environmental factor that affects soaking duration?
5) For how long should seeds be soaked at room temperature (27°C)?
6) During incubation, why should you not allow seeds to become too hot or too cold?
7) How much should the shoot have grown after 24 hours of incubation of seeds? After 48 hours?
8) Why is it advisable to allow 24 hours of incubation for seeds intended for wetbed or direct seeding, and 26 to 48 hours of incubation for seeds intended for dapog seedbed?

4. SELECTING SEED BY SPECIFIC GRAVITY

Objectives: To learn how to separate well-filled seeds from unfilled seeds by their difference in specific gravity; to prepare a salt solution for such a purpose; and to determine the required amount of seeds to be planted given the area, seeding rate, and percentage of germination.

Materials: For each group of trainees:

- 3 kg common salt
- 4 kg ammonium sulfate
- Clean water
- Hydrometer, or a fresh hen's egg
- Container, 12-liter capacity
- Stirrer
- Balance, 5-kg capacity
- Seed of various varieties, at least 2 kg for each group

INTRODUCTION

Although most of the unfilled seeds, straw, and dirt can be removed by winnowing, some unfilled seeds still will remain with the good ones. The unfilled seed portion will alter the accuracy of the calculation for the required amount of seed. It is therefore advisable to determine the portion of unfilled and light seeds before soaking them.

PRESENTATION

Seeds may be prepared either mechanically or by the specific gravity method. Seeds may be separated mechanically by (1) using air as in winnowing in which the lighter seeds are blown out, or (2) using a gravity table on which the lighter seeds tend to separate and remain on the side of the slightly sloping table surface which is jiggled mechanically.

You can also use a salt solution of a certain specific gravity to separate seeds. The light seed will float and can be removed from the surface. Procedure:

Steps	Key points
1 Obtain seed sample	a) Mix the seeds to be tested well and sample at random. b) Weigh exactly 1 kg. c) Note the variety.
2 Prepare a salt solution	a) For traditional tropical varieties (indica), use a solution with a specific gravity of 1.08. Mix 1.65 kg of *common* salt in 10 liters of clean water. If ammonium sulfate is used instead of common salt, mix 2.20 kg ammonium sulfate in a bucket containing 10 liters of clean water. b) For traditional temperate varieties (japonica) use a solution with a specific gravity of 1.13. Mix 2.50 kg of common salt *or* 3.10 kg of ammonium sulfate in a bucket containing 10 liters of clean water. c) The desirable specific gravity can be checked accurately by a hydrometer or, approximately, by using a *fresh* chicken's egg: (1) the specific gravity is approximately 1 when one end of the egg surface just breaks the solution surface (Fig. 1). (2) the specific gravity is approximately 1.13 when the surface area of the egg above the solution surface reaches a diameter of about 20 mm.
3 Add the seed sample	a) Stir the seeds thoroughly in the solution. b) Allow seeds to settle.

4 Remove floating seeds	a) Carefully remove all floating seeds. Avoid spilling them on the ground. b) Spread them on a piece of cloth or sack, and let dry.
5 Wash the good seeds	Drain the bucket and wash the good seeds thoroughly in fresh water to remove salt.
6 Dry the seeds	Thoroughly dry both the good and floating seeds. Save the good seeds for planting and process the floating (unfilled) seeds as in Step 7.
7 Weigh the unfilled seeds	a) Before weighing, the unfilled seeds must be thoroughly dry. b) Record the weight in grams.
8 Calculate the percentage of unfilled seeds	a) The percentage of unfilled seeds is: $\frac{\text{Weight of unfilled seeds (g)}}{\text{total weight of seed sample (g)}} \times 100$ b) Since in Step 1 we took 1 kg (1,000 g) as the total weight of seed sample, the above equation can be simplified: $\% \text{ of unfilled seed} = \frac{\text{weight of unfilled seed (g)}}{10}$
9 Report results	a) Report the percentage of unfilled seeds in the sample. b) Result is more reliable if at least 2 tests are made on the same source of seeds.

Note that satisfactory results may often be obtained with clean water alone instead of a salt solution. Clean (but not pure) water has a specific gravity of 1 or more. It works well with new improved rice varieties.

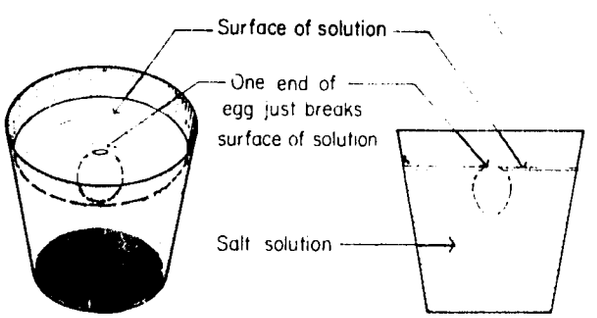


Fig. 1. When the specific gravity of a solution is approximately 1, one end of the fresh egg barely touches the solution surface.

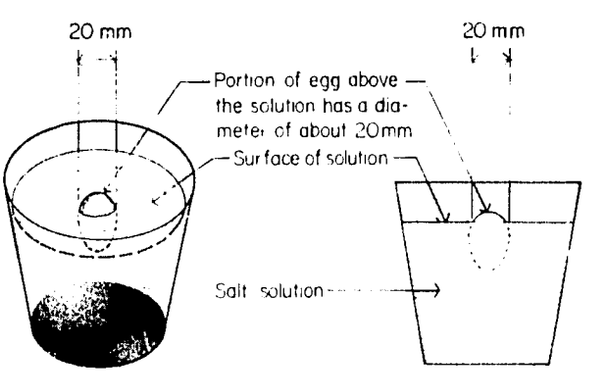


Fig. 2. When the specific gravity of a solution is approximately 1.13, one end of the fresh egg intersects the solution surface making an area of 20 mm in diameter.

Seed computation

If the rate of seeding, the percentage of germination, and the percentage of unfilled seed are known, the required weight of seeds to plant a given area is:

$$\frac{\text{Seeding rate (kg/ha)} \times \text{area to be planted (sq m)}}{\frac{\text{\% germination}}{100} \times \frac{\text{\% filled grain}}{100} \times 10{,}000 \text{ (sq m/ha)}}$$

or

$$\frac{\text{Seeding rate (kg/ha)} \times \text{area to be planted (sq m)}}{\text{\% germination} \times \text{\% filled grain}} = \text{seed required (kg)}$$

Example: If a stock of IR20 has 90 percent germination and 2 percent unfilled grain, what is the required weight of this seed to plant 600 sq m at a seeding rate of 20 kg/ha?

Step 1 — The percentage of filled grain = 100 - 2 = 98%
Step 2 — Required weight of seed (20 x 600)/(90 x 98) = 1.361 kg

APPLICATION

Each group of trainees will be given one variety of seed for the following tests:

1) By duplicated trials, determine the percentage of unfilled grains in the assigned stock of seeds by specific gravity using three media:
   (a) common salt solution
   (b) ammonium sulfate solution
   (c) clean water
2) Compare the relative effectiveness of each medium and recommend medium to be used.
3) Compute the weight of seeds required to plant 400 sq m at a seeding rate of 40 kg/ha. Germination is 88%

EVALUATION

1) Cite the ways by which seed separation can be accomplished.
2) Why is it necessary to determine the percentage of unfilled grains?
3) What is the recommended specific gravity of salt solution for *indica* varieties? For *japonica* varieties? Is this difference significant?
4) For practical purposes the unfilled seeds were removed from the salt solution and dried. What may affect the dry weight of these unfilled seeds?
5) Why should unfilled seeds be weighed only after being dried?
6) What is the advantage of using clean water instead of salt solution?
7) What is the first step in computing for the required weight of seeds to plant a given area if the percentage of germination and that of unfilled seeds, and the seeding rate are known? What is the second step?
8) What are the key points you should remember when performing these computations?
9) Problem 1: Given:

seeding rate	40 kg/ha
germination	85%
unfilled grain	4%
area to be planted	1/4 ha

Compute for the required weight of seeds to be soaked.

Problem 2: Given:

seeding rate	20 kg/ha
germination	78%
unfilled grains	5%
area to be planted	2.5 ha

How much seed is needed?

5. RAISING SEEDLINGS BY WETBED METHOD

Objectives: To be able to create a favorable puddled soil condition for planting pregerminated seeds; to deposit the right amount of seeds on a given wetbed area; to protect the seedling nursery from insect pests, water shortage, and nutritional disorders; to make easier subsequent pulling of seedlings; to pull seedlings from wetbed at the proper time; and to prepare seedlings for transplanting.

Materials: Each group of trainees will need:

Seeds, incubated for 24 hours
1 meter stick, or steel tape
Sufficient prepared land area to permit all trainees to practice the various skills
Sevin 85 WP, sufficient for the area chosen
Sprayer for insecticide
Abaca, or banana twine of sufficient lengths to outline seedbed area and bundle seedlings
4 bamboo stakes, each 1 x 2 x 40 cm for each seedbed

Teaching aids: Slides showing steps involved in raising seedlings by wetbed method

INTRODUCTION

There are three major methods of raising seedlings: the wetbed method, the dapog method, and the drybed method. This lesson deals with the wetbed method which makes the most economical use of seed in producing seedlings. Wetbed seedlings can be planted at a definite number per hill. It is a method that conserves seeds, e.g. a small amount of seeds of a new variety. If the wetbed method is used you will be able to calculate the specific amount of seeds required with little waste.

PRESENTATION

Raising seedlings by the wetbed method involves four operations: (1) preparing the seedbed, (2) sowing seeds, (3) taking care of seedlings in the seedbed, and (4) pulling seedlings.

Operation 1. *Preparing the wetbed*

Steps	Key points
1 Compute for the area required for constructing a seedbed	a) Rate of seeding should be approximately 100 g/sq m of seeds. b) To obtain the required area of seedbed, divide the weight (in grams) of seeds to be planted by 100 (see Soaking and Incubating Seed). c) Each seedbed should be about 1.5 m wide to facilitate subsequent seedbed management. d) If more than one seedbed is needed, give allowance for canals (40 cm wide) between seedbeds (Fig. 1).
2 Select the location	The field should be: a) conveniently located for irrigation and drainage, safe from uncontrolled flood; b) fertile, free of excess salts, or other soil problems; c) sunny and warm, in full sunlight; and d) large enough to provide seedlings with sufficient space to obtain required nutrients, water and light.
3 Prepare the land	Land must be prepared 30 to 35 days before planting time (see Land preparation).

4 Regulate water level	Drain off excess water or admit no more water than required to maintain a water level just sufficient to cover the soil. This will serve as a guide in levelling the soil.
5 Measure area of seedbed	a) Two persons can easily perform this operation. b) For each seedbed, use a string or twine, and four bamboo stakes to outline the predetermined area with the help of a steel tape or other measuring devices (Fig. 1).
6 Raise seedbed level	a) Collect mud around and outside of the string to put in the area thus outlined. The result is a canal formed as height of seedbed increases. Therefore if a second seedbed is to be constructed adjacent to the first one, do not collect soil inside the area of the second seedbed. b) Seedbeds preferably should be about 4 to 5 cm above the original soil level. c) Smooth the surface of the seedbed so that there is gradual inclination toward both sides to facilitate drainage of water (Fig. 2) during the first few days.

Operation 2. *Sowing the seeds*

Step	Key points
1 Sow the seeds	a) Seeds must have been pregerminated for 24 hours. b) Broadcast evenly about two to three handfuls of seeds on a square meter of seedbed i.e. approximately 100 g of seeds per square meter (Fig. 2). CAUTION: If seeds are sown too closely seedlings will be smaller. It will also be more difficult to pull seedlings and there will be more chances of injuring the long roots of adjacent seedlings.

Operation 3. *Care of wetbed seedbed*

Steps	Key points
1 Protect seedlings from lack of water	a) During the first week, add just enough water to saturate the soil. b) After the first week, irrigate the seedbed gradually and continuously to a depth of 5 cm, depending upon the height of seedlings, to control weeds.
2 Protect seedlings from insects and animals	a) Every 7 days, spray Sevin 85 WP at a rate of 0.09% toxicant (active ingredient) or 1 level tablespoon per 10 liters of water (Fig. 3). Other local insecticide recommendations may be used. b) If possible, fence the seedbed to protect it from rats, water buffaloes, birds, etc..
3 Protect seedlings from nitrogen deficiency	If you observe symptoms of nitrogen deficiency, broadcast 50 to 100 g of ammonium sulfate per square meter of seedbed (*or* use 20 to 40 g of urea per square meter).

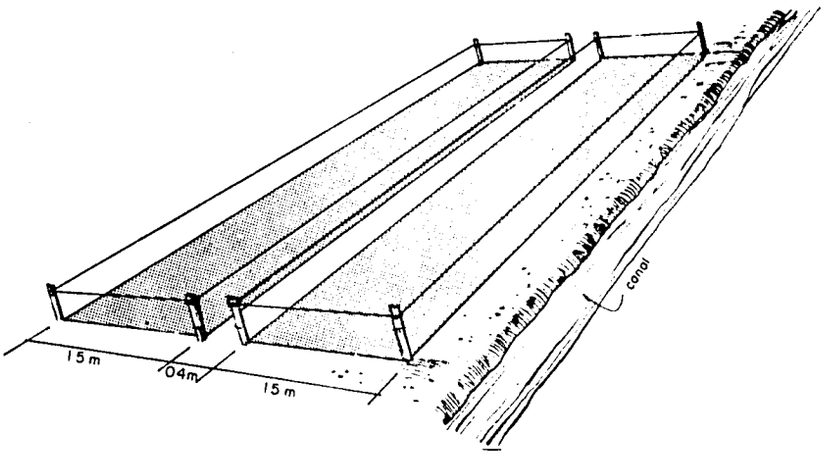


Fig. 1. Measuring area of seedbeds.

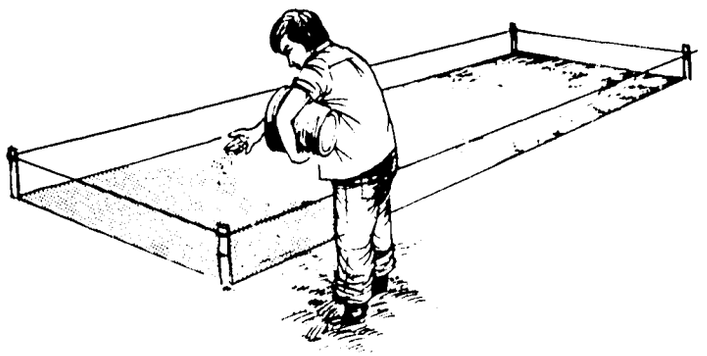


Fig. 2. Sowing of seed on seedbed.

Operation 4. *Preparing seedlings for transplanting* (Pulling of seedlings)

Steps	Key points
1 Pull seedlings	a) Seedlings are ready for transplanting from 20 to 25 days after sowing. Seedlings more than 30 days old when transplanted recover more slowly than younger seedlings, especially if they suffer stem and root injury. Seedlings less than 18 days old are difficult to pull from the soil. b) Grasp two to three seedlings at a time. c) Hold the seedlings between the thumb and four fingers as shown in Fig. 4. d) Hold seedlings as close to the base as possible. e) Pull gently at an angle about 30° from the horizontal as in Fig. 4. f) When seedlings are intended for research do not pull those on the edges of the beds since they are not uniform.
2 Clean roots	a) If too much mud sticks to roots, wash by shaking the roots in water. b) Do not strike plant roots against your feet or any object to remove mud as this will injure the plants.
3 Bundle the seedlings	a) A convenient size of seedling bundle is between 5 to 8 cm (2 to 3 inches) in diameter. b) Use any soft material, such as banana or abaca twine for tying. c) Protect seedlings from drying.

Fig. 3. Spraying seedbed with insecticide at 7-day intervals to protect seedlings from insects.

Fig. 4. Pulling seedlings.

Characteristics of good rice seedlings from wetbed

1) They are of uniform size and are easy to pull and transplant.

2) They are free of diseases and pests and from damage caused by these sources. Mechanical injury should be minimized.

3) They are tough and have short but erect leaves and vigorous roots; they recover quickly after transplanting.

Advantages of wetbed method

1) Less seeds are required per unit area to be transplanted.

2) Seedlings are easily managed in transplanting.

3) Number of seedlings per hill can be specified; therefore not many seedlings are wasted.

4) It is suited for experimental purposes.

Disadvantages of wetbed method

1) It requires land area for seedbed.

2) Preparation of seedbed, care of seedbed and pulling of seedlings are laborious.

3) Seeds are easily carried away by raindrops if a heavy rain occurs shortly after seeds have been sown.

APPLICATION

1) Compute the area required for a wetbed sufficient for 6 kg of seeds. If the length of the area is 10 m, how many strips of seedbed are needed?

2) Assign each group of trainees an area where they can perform Operation 1 through Operation 4. Check each trainee's performance against the key points prescribed in each operation.

EVALUATION

1) When is the wetbed method preferable?

2) Cite one important factor to consider when selecting a location for a wetbed.

3) What is the recommended seeding rate for a wetbed seedbed?

4) Why is the width of seedbed usually taken as 1.5 m?

5) If two seedbeds are to be constructed side by side, what precaution should you take when raising the seedbed level with mud?

6) What is usually the height of seedbeds?

7) What is a practical guide in levelling the surface of a seedbed?

8) How do you facilitate the flow of water on the seedbed during the first few days after sowing?

9) What is one practical way of broadcasting the right amount of seed on a wetbed seedbed?

10) Why should seeds not be sown too closely?

11) Why should you not flood the wetbed seedbed during the first week after sowing? And why should you flood the seedbed after this period?

12) Describe how seedlings in the seedbed are protected from insect pests, and other animals.

13) At what age should the wetbed seedlings be transplanted? Why?

14) What precaution should be observed while pulling to prevent injury to seedlings?

15) Why should border seedlings not be used when seedlings are intended for research?

16) Cite one precaution in handling pulled seedlings.

17) What are the advantages of the wetbed method? the disadvantages?

18) Prepare a schedule of work designed for raising of wetbed seedlings. Schedule must start from time of land preparation for seedbed and end with time of pulling seedlings.

6. RAISING SEEDLINGS BY DAPOG METHOD

Objectives: To be able to properly construct a dapog seedbed with banana or plastic materials; to deposit the right amount of seeds on a given dapog seedbed area; to maintain compactness of germinated seeds in the dapog seedbed, and thus insure a uniform growth of seedlings; and to protect the seedling nursery from insect pests, water shortage, and nutritional disorders.

Materials: Each group of trainees will need:
Seeds, already incubated for 36 to 48 hours, sufficient for desired area
Meter stick, or steel tape
Prepared land area sufficient for training objective
Enough banana leaves to prepare size of bed needed
Banana bracts from one whole mature banana stalk
20 bamboo sticks, each 0.5 x 1.0 x 15.0 cm
4 bamboo stakes, 1 x 2 x 100 cm, for each seedbed
Stick broom, or gardener's sprinkler
Woodboard with handle (See Fig. 1)

Teaching aids: Overhead projector transparencies
Color slides showing steps involved in the production of seedlings by dapog method

INTRODUCTION

This lesson deals with the dapog method of raising seedlings. The method is most commonly used in the Philippines and is gaining popularity in other countries. If a farmer cannot afford a large area for his seedbed and wishes to reduce the time required to produce seedlings and to save labor in pulling seedlings, he may want to try the dapog method of raising seedlings.

PRESENTATION

The dapog method consists of four operations: (1) preparing the dapog seedbed, (2) sowing seeds, (3) caring for the dapog seedbed, and (4) preparing seedlings for transplanting.

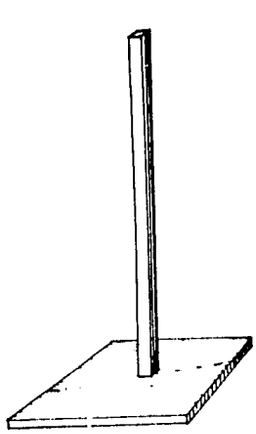


Fig. 1. A woodboard with handle.

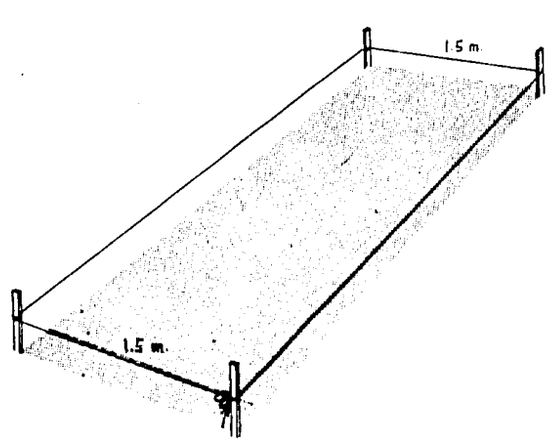


Fig. 2. A measured seedbed area should be about 1.5 meters wide.

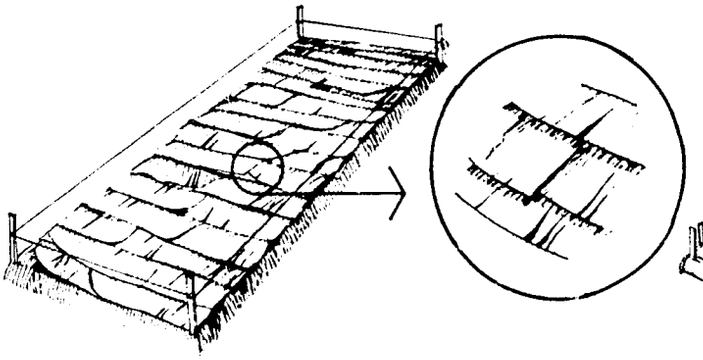


Fig. 3. A seedbed surface covered with overlapping banana leaves.

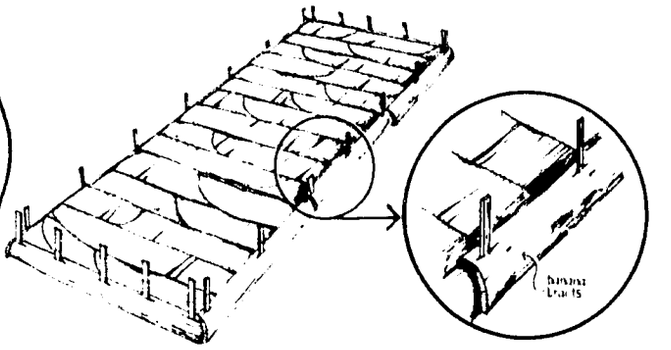


Fig. 4. Seedbed surrounded by banana bracts which are held in place by bamboo sticks.

Operation 1. *Preparing the dapog seedbed*

Steps	Key points
1 Compute area required	a) Approximately 1 sq m of seedbed is required for every 3 kg of seed. b) Width of seedbed is conveniently taken at 1.5 m for easy management.
2 Prepare the land	Usually one plowing followed by one harrowing is sufficient.
3 Regulate water level	a) There must be enough water to cover the soil surface. b) This will serve as a guide in levelling the soil.
4 Measure area	a) Two persons can easily perform this operation. b) For each seedbed use a string, or twine, and four bamboo stakes to outline the predetermined area with the help of the steel tape or other measuring devices (Fig. 2).
5 Raise seedbed level	a) Collect mud around and outside the area outlined by the string and transfer it to the enclosed area. A canal is formed around the bed as height of seedbed is increased. b) Height of each seedbed is preferably about 4 to 5 cm above the original soil level. c) Smooth and level the surface of the seedbed.
6 Cover the soil of seedbed	a) Use banana leaves with midribs removed. Plastic sheets if available, may be used instead of banana leaves. b) Spread the leaves with the powdery or underside up. c) The leaves should overlap each other and should have no hole or breakage. Then cover the surface of the seedbed evenly and completely (Fig. 3).
7 Surround the seedbed with banana bracts	a) Carefully lay strips of banana bracts along the periphery of the seedbed. b) Pierce through the bracts and into the soil with thin bamboo pegs to keep the bracts upright and firmly in place (Fig. 4).

Alternative procedure

If cemented floor is available, you may use it instead of prepared land. All you need is an enclosure as described in Step 6 above. A cemented floor constructed especially for dapog seedbed is shown in Fig. 5.

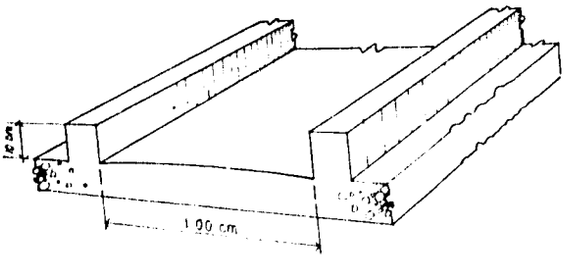


Fig. 5. Portion of cemented floor for raising dapog seedlings.

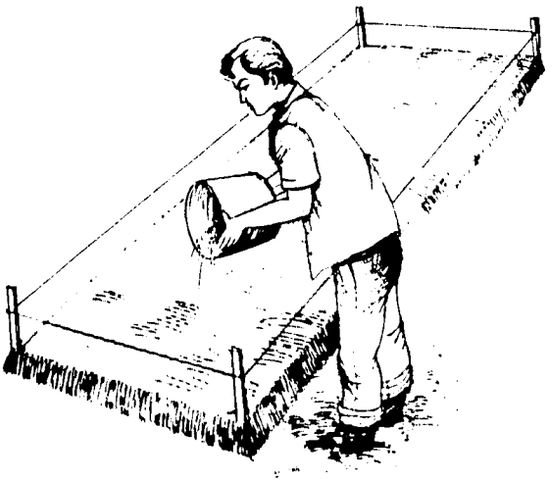


Fig. 6. Scatter pregerminated seeds over the banana leaf enclosure.

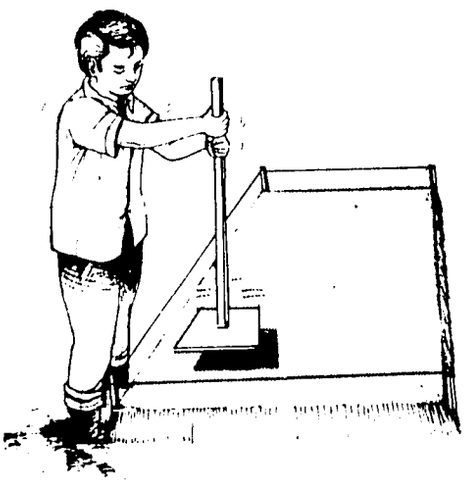


Fig. 7. Pack the seeds with a wooden levelling board to make a uniform layer of three-seed thick.

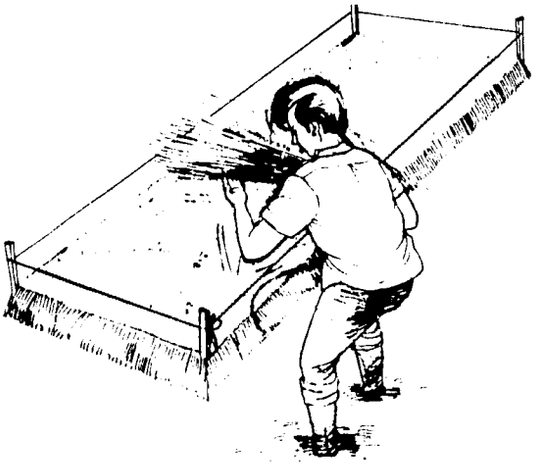


Fig. 8. Sprinkle water onto the seedbed with a stick broom three to four times a day.

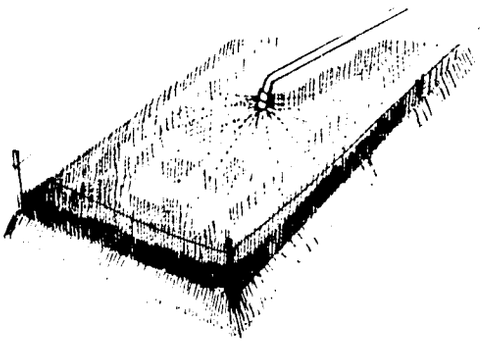


Fig. 9. Spray insecticide on seedbed and 2 to 3 meters around all sides to protect seedlings.

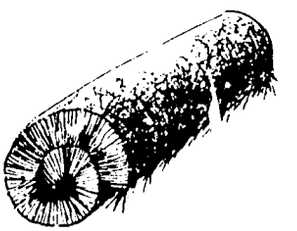


Fig. 10. Rolled dapog seedlings ready to be transported to the planting area.

Operation 2. *Sowing seeds*

Steps	Key points
1 Scatter the pregerminated seeds over the banana leaf enclosure	a) Seeds must have been pregerminated for 36 to 48 hours. b) Pack the seeds to make a uniform layer three seeds thick (approximately 3 kg of seeds per square meter). Use a levelling woodboard to press the seeds (Fig. 6 and 7). c) Do not press heavily on the seeds or you will squeeze out the mud underneath, thus destroying the flatness of the seedbeds.
2 Water the seeds	Immediately after obtaining a uniform layer of seeds, sprinkle water onto them using a stick broom or a gardener's sprinkler. Do not pour water or you will displace the seeds.

Operation 3. *Care of dapog seedbed*

Steps	Key points
1 Protect seedlings from lack of water	a) Water the seedbeds three to four times a day with a gardener's sprinkler or a stick broom. Never let the seedbed dry (Fig. 8). b) After 4 days irrigate the seedbed continuously to a depth of 1 to 2 cm of water.
2 Maintain an even germination	By hand or with a woodboard lightly press the seeds once a day until the fourth day. This keeps the roots of the seedlings in contact with the banana leaves or plastic sheet.
3 Protect seedlings from insect pests and animals	a) On the fifth and tenth day spray Sevin 85 WP at 1 level tablespoon per 2 liters of water (or 0.09% active ingredient) on seedbed and also 2 to 3 m around all sides (Fig. 9). However, local insecticide recommendations may be followed. b) Fence the seedbeds to protect them against rats, water buffaloes, birds, etc.

Operation 4. *Prepare seedlings for transplanting*

Steps	Key points
1 Loosen and roll the seedbed into a convenient bundle	a) Dapog seedlings are ready for transplanting when 10 to 14 days old. b) As the bed is rolled, leaves turn inward and roots outward. c) If the roll is too large cut it crosswise into convenient pieces (Fig. 10).
2 Bring roll of seedlings to the field to be planted	

Characteristics of good rice seedlings from dapog seedbed

1) They have a uniform size.
2) They are free of diseases and pests, and from damage caused by them or from mechanical injury.
3) They are hardy, having short but erect leaves and vigorous roots.

Advantages of dapog method

1) Time in the seedbed is greatly reduced.
2) Area required for seedbed is reduced.
3) More choices for location of seedbed.
4) Seedlings do not suffer from root or stem injury.
5) Pulling of seedlings is eliminated.
6) Seeds in seedbed will not be carried away by rain.

Disadvantages of dapog method

1) A larger quantity of seeds is required.
2) Seedlings are short.
3) Number of seedlings per hill cannot be controlled easily.

APPLICATION

1) Compute the area required for a dapog seedbed needed for 20 kg of seeds:

Since each square meter of seedbed is required for 3 kg seeds, 20 kg seeds requires:

$$20/3 = 6.66 \text{ sq m}$$

If the width of the seedbed is 1.5 m, its length should be:

$$6.66/1.5 = 4.44 \text{ m}$$

2) Have each group of trainees perform Operations 1 through 4. Check each trainee's performance against the key points prescribed in each operation.

EVALUATION

1) When is the dapog method preferable?
2) What is the seeding rate for a dapog seedbed?
3) Why is the width of dapog seedbed usually taken as 1.5 m?
4) Why must canals be provided around dapog seedbeds?
5) Describe a practical guide in levelling seedbeds.
6) How are banana leaves used in making the flooring of a dapog seedbed?
7) How are banana bracts held in place at the edges of the dapog seedbed?
8) Explain the versatility of dapog seedbeds.
9) What is the incubation period for seeds intended for dapog seedbeds? Why?
10) Why should seeds be pressed with wooden board during the first four days?
11) What care should be taken when watering the dapog seedbed?
12) When do you apply insecticide to protect seedbeds from insect damage?
13) When is a dapog seedling ready for transplanting? Why should you not wait for 20 days?
14) Cite three characteristics of good dapog seedlings.
15) What are the advantages and disadvantages of dapog method?
16) Prepare a schedule of work designed for raising seedlings by dapog method. Time should cover land preparation to removal of seedlings from seedbed.

3. PREPARATION FOR PLANTING

1. THE PLANTING WIRE AND BOARD

Objective: To be able to prepare a planting wire and board.

Materials: For each group of trainees:
1 wooden board, 5 x 15 x 200 cm
2 wooden boards, 2 x 5 x 200 cm
50 nails, each 5 cm long
Meter stick or any other measuring device
Iron bars, diameter 8 mm, bent at both ends right angle to the bar and to each other (Fig. 1)
Iron wires, type No. 18 (about 2 mm in diameter) 20 m long

INTRODUCTION

Most rice farmers prefer transplanting in straight rows to broadcasting mainly because transplanting allows better management after planting. One way to accomplish straight-row planting is by use of the planting wire and board.

PRESENTATION

Operation 1. *Making a planting wire*

Steps	Key points
1 Mark spacings on the wooden plank	a) Use a board, 5 x 15 x 200 cm. b) Take note of the spacing to be adopted. c) Using as a guide a steel tape or meter stick, put a pencil mark at every spacing desired and double check the distance. d) Drive two nails on both sides of each mark. Each nail should be 0.5 cm from each mark and 1 cm from the side of the plank (Fig. 2).
2 Mark spacings on the planting wire	a) Drive a nail at one end of the plank and tie one end of the No. 18 wire to it. b) With a bent iron bar held at the side nearest the first pair of nails, pass the wire between them and over the iron bar, then back between the nails. c) Twist the wire by turning the bar three times while *slightly* stretching the wire. *Do not stretch too strongly nor turn the bar more than three times.* The result is a round loop (Fig. 3). d) Continue with the next loop and so on until a desirable length of the planting wire is reached.

Alternative procedure. Many workers have found that nylon cord (about 2 mm in diameter) can be used. In this case strips of rubber (about 2 cm in diameter) are attached to the nylon cord to mark the spacing. After washing, the material is like new, and can be used for a long time.

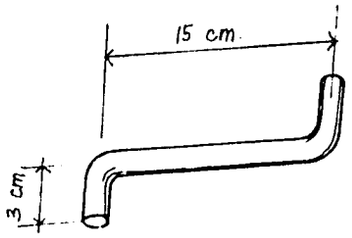


Fig. 1. An iron bar used in preparing planting wire.

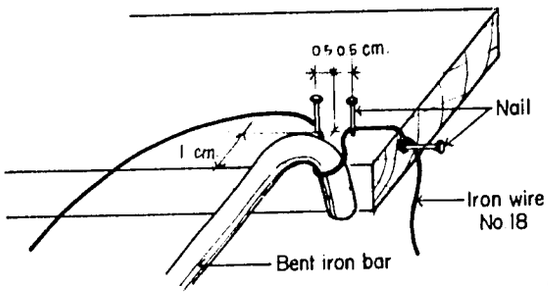


Fig. 2. The first step in making a wire loop is to insert the iron bar between the iron wire and the nails.

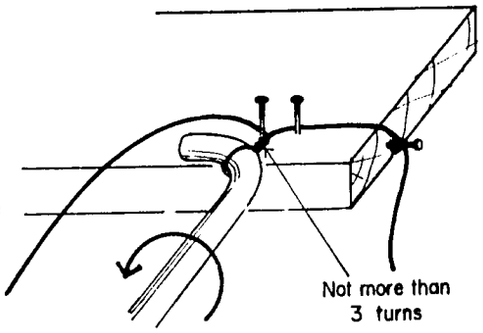


Fig. 3. Forming a loop on the iron wire.

Operation 2. *Making a planting board*

Steps	Key points
1 Mark the spacings with pencil on the board	a) Use a board of about 2 x 5 x 200 cm. b) Note the spacing to be adopted. c) Using a steel tape or meter stick as a guide, put a pencil mark at every spacing desired.
2 Drive nails at the spacings	a) Drive a nail into each pencil mark. b) Certify the spacings after all nails are mounted by checking the distance between every two nails.

APPLICATION

Each group of trainees will prepare a 20-meter planting wire and two 2-meter planting boards. (Each loop on the wire should be formed by no more and no less than three turns and the wire should not be stretched tightly.)

EVALUATION

1) Cite one reason why straight row planting is essential in rice production.
2) When marking the spacings on the wooden plank, why are two nails needed at each mark, rather than one?
3) What will happen if you stretch the wire too tightly?
4) What will happen if more than three turns are made at each loop?
   What may happen if less than three turns are made at each loop?

2. LAYING OUT PLOTS

Objective: To be able to set up boundaries of individual plots given a planting plan or an experimental design.

Materials: Each group of trainees will need:

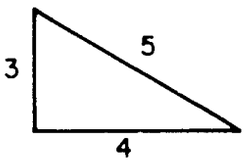
A 20-meter or longer steel tape
40 bamboo stakes
50 meters of abaca twine

Teaching aids: Overhead projector transparencies showing steps in laying out an experimental plot
Slides showing correctly laid out plots

INTRODUCTION

Meaningful experimental results depend partly on an exact plot layout. A correct plot layout facilitates both transplanting in straight rows and the construction of levees required by the planting plan.

PRESENTATION

Steps	Key points
1 Study the plan of planting	Carefully note the size of the entire area, the length, width, and number of treatments or replications.
2 Establish the first base line	a) Stake two points and tie abaca twine between them. b) Preferably, make the first base line parallel to one of the border levees. c) Distance between the levees and the base line will depend upon the purpose of the planting.
3 Establish the second base line	a) Stake two other points and stretch an abaca twine so that it is perpendicular to the first line. b) Right angles between the two base lines may be established by using a notebook or applying the Pythagorean equation: $3^2 + 4^2 = 5^2$  A right angle c) Distance between the levees and the base line varies depending upon the purpose of the planting.
4 Measure the sides of the entire plot	a) Measure the length and width first along the established base lines. Mark with stakes. b) Then stake the fourth corner by measuring out the same length and width.

5 Measure the individual plots	a) Measure the sides of treatment plots, alleyways, and replications. Mark them with stakes. b) Do this on opposite lengths and widths. c) Connect corresponding stakes with string.

Levees may be constructed after the outline has been established.

Note: Before transplanting, the two base lines established in Steps 2 and 3 should be retained to serve as guide for planting wire and boards.

APPLICATION

1) Have trainees draw on paper a plan for an experimental design with the following details:
   a) 3 replications
   b) 5 treatments
   c) Size of each treatment plot: 3 x 5 m
   d) Alleyways, 40 cm wide
   e) Levees, 20 cm wide
2) Submit the plan to the instructor for checking.
3) Have trainees practice laying out the plan on the lawn.

EVALUATION

1) Why do experimental results depend partly on a careful plot layout?
2) Give one reason for the establishment of the first two perpendicular base lines prior to transplanting.
3) How do you check whether two lines are at right angles?

3. TRANSPLANTING

Objectives: To be able to establish a stand of rice by transplanting the seedlings.

Materials:
1 piece planting wire, long enough to cross the paddy being planted
2 planting boards, each 2 m long
2 bamboo poles, each about 2 m long
Seedlings from wetbed and dapog seedbeds
Field, thoroughly plowed and harrowed

Teaching aids:
Overhead projector
Slides showing steps in transplanting

INTRODUCTION

Proper plant development can only be attained if the crop is well managed from planting to harvesting. Management will be much easier if the field is planted in straight rows. You can do weeding by hand or mechanically, and spray insecticides or broadcast fertilizers without substantially damaging the rice plants. Straight-row planting can be done by direct row sowing or by transplanting. This lesson deals with transplanting, a common method of establishing a stand of lowland rice.

PRESENTATION

Transplanting is done only when the land has been thoroughly plowed and harrowed, properly fertilized, and excess water drained off to not more than 1 cm deep.

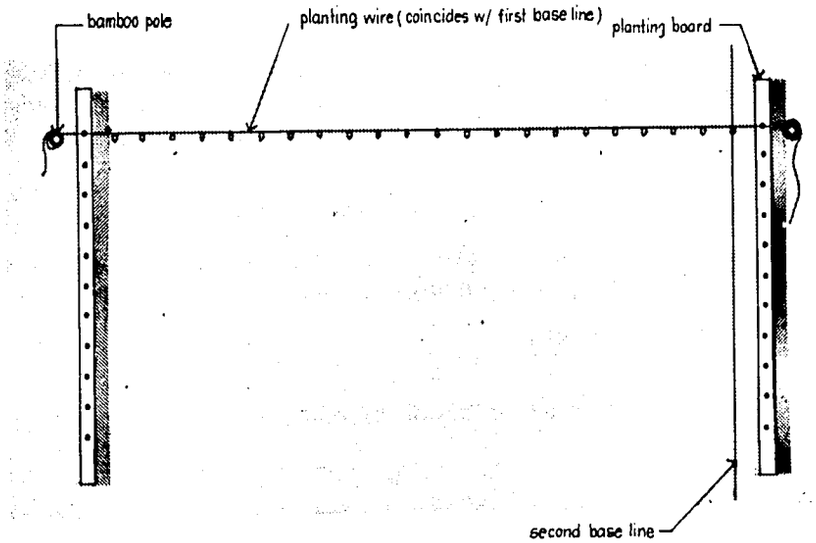


Fig. 1. Setting up of planting wire and boards before transplanting.

Fig. 2. Holding a rice seedling during planting.

Steps	Key points
1 Place planting wire	a) Stretch the wire along the first base line (established in Step 2 of "Laying out plots"). b) Drive a bamboo pole into the ground at each end at the first base line. c) Tie each end of the wire to a bamboo pole so that the wire is about 10 cm above the soil level.
2 Place planting boards	a) Place one planting board along the second base line (Step 3 in "Laying out plots") so that the first marking on the board coincides with the first base line (Fig. 1). b) Place the second planting board opposite the first one. Its first marking should coincide with the first base line.
3 Distribute seedling bundles throughout the plot	
4 Set planters along planting wire	
5 Plant the seedlings	a) Hold seedling bundle in such a way as to facilitate detaching the seedlings. b) Detach the right number of seedlings from the bundle, protecting the roots by keeping them in three fingers (Fig. 2) while inserting them into the soil right under a mark on the planting wire. Plant not shallower than 1.5 cm but not deeper than 3 cm (wetbed seedlings). c) Make sure the planting wire is stretched while you are planting. d) When the first row has been planted, move the planting wire to the next row using the next mark on each of the planting boards as the end points of a new row. e) Move backwards to plant subsequent rows.
6 Save extra seedlings	Collect all extra seedlings and plant a whole bundle at one alleyway for replanting.
7 Clean up	When the last row has been planted, remove planting wire, boards, and base lines and clean them thoroughly.
8 Maintain shallow water level	After transplanting keep water depth at about 1 cm until the plants recover (generally for 3 to 4 days).
9 Replace missing hills	Ten days after transplanting, replace all missing hills with extra seedlings previously saved (Step 6) or from new tillers of neighboring hills.

Advantages of transplanting in straight rows

1) Weeding in two directions with a rotary weeder or by hand is possible; thus, weeding operations are more efficient.

2) Proper plant spacing makes uniform growth of plants possible.

3) Other field management operations, such as spraying and fertilizer topdressing, are made easier.

Disadvantages of transplanting

1) Labor cost is high.

2) Seedlings are exposed to possible injury during handling.

3) Plants tend to grow more slowly than if seeded directly because of recovery time after transplanting.

4) Harves ng is delayed from a week to 10 days.

Depth of transplanting

The most preferable depth of transplanting is from 1.5 cm to 3 cm. If the seedlings are placed too deeply, the old roots suffer and new roots develop from a node close to the soil surface. This is called "node rooting." It may delay the normal absorption of nutrient elements from the soil, thus delaying plant recovery. On the contrary, too shallow transplanting will keep the seedlings from being held in place and erect, especially when the wind is strong.

APPLICATION

1) Have the trainees pull their own seedlings.
2) Have all trainees practice transplanting on a well-prepared plot.
3) Have each group of trainees transplant the seedlings of their applied research in their assigned plots.

EVALUATION

1) Why do farmers still prefer transplanting despite its cost?
2) Why is it not advisable to transplant when the field has more than 1 cm of water?
3) What may happen when transplanting on a field which is completely drained?
4) How do you position the planting wire? And the planting boards?
5) How can you protect seedlings while inserting them in the mud while transplanting?
6) Why is it not advisable to plant deeper than 3 cm (wetbed seedlings)?
7) Cite four disadvantages of transplanting.

4. DIRECT SEEDING

Objectives: To be able to plant a specific amount of rice seeds directly in a unit area of granulated dry soil or puddled soil by straight-row drilling or broadcasting.

Materials: Seeds soaked for 24 hours and incubated for at least 24 hours, and dry seeds
Grain drill, a six-row or eight-row seeder

Teaching aids: Slides showing operation of the IRRI eight-row seeder

INTRODUCTION

Direct seeding greatly reduces labor cost for establishing a stand of rice. But to get maximum results, you must use the most profitable amount of seeds per unit area, and prepare the land as required for the different methods of seeding.

PRESENTATION

There are four methods of direct seeding: (1) drilling in dry granulated soil, (2) broadcasting on puddled soil, (3) broadcasting in water, and (4) drilling on puddled soil.

In any method, the optimum seed rates range from 50 to 100 kg/ha. Low-tillering varieties usually require higher seeding rates than high-tillering ones. Thus, direct seeding calls for more seeds to plant a given area.

A. *Drilling in granulated soil*

Steps	Key points
1 Prepare the soil	a) Do this only when soil is dry. b) Plow and harrow until big clods are pulverized. c) Make shallow furrows, 10 to 15 cm deep and about 1 meter apart, to facilitate irrigation. d) Do not irrigate before seeding.
2 Sow the seeds	With a grain drill, drill the seeds (which have not been pregerminated) 2 to 4 cm below the soil surface.
3 Irrigate the field	After drilling, let water enter the field through furrows. Do not flood the field.
4 Flood the field	Three to four weeks after seeding, flood the field continuously with water if available.

An advantage of this method is that it requires less water than does drilling in puddled soil, but seedlings develop more slowly in the early stage.

B. *Drilling in puddled soil*

Steps	Key points
1 Prepare the soil	a) Soil must be well puddled (see Land Preparation). Make canals around the plot for drainage if rainfall is expected shortly after seeding. b) Drain all excess water from the field before drilling.
2 Sow the seeds	a) With an eight-row or six-row seeder (developed by IRRI), drill the pregerminated seeds (soaked for 48 hours and incubated for 24 hours). Seeds will stick to the bottom of the furrow opened by the seeder if the soil is well puddled and the water is drained just before seeding. b) Do not flood field right after seeding.
3 Irrigate the field	Two days after seeding, gradually raise water level in the field to about 1 cm below the tips of most seedlings until a level of 5 cm is reached.

An advantage of this method over the broadcast method is that weeding by rotary weeder is possible. However, seeds that are not covered by mud are exposed to bird and rat damage.

C. *Broadcast on puddled soil*

Steps	Key points
1 Prepare the soil	See Step 1 of Drilling in Puddled Soil.
2 Broadcast the seeds	Use pregerminated seeds.
3 Irrigate the field	a) Do not irrigate immediately after seeding. b) Gradually let in water to 5 cm after seedlings are 10 cm tall.

An advantage of this method is that seedlings develop rapidly. The newly sown seeds are, however, exposed to damage by rat, bird, and unexpected heavy rainfall.

D. *Broadcast in water*

Steps	Key points
1 Prepare the soil	See Step 1 of Drilling in Puddled Soil.
2 Flood the soil	Irrigate the field to 2 to 10 cm deep.
3 Sow the seeds	a) Allow soil particles to settle before sowing. b) Broadcast the seeds uniformly over the entire area. Use pregerminated seeds.

The advantages of this method over broadcasting on puddled soil are better early weed control and protection of seeds from bird and rat damage. Emergence of seed is retarded, however. The seeds tend to float if water becomes too muddy.

APPLICATION

Have trainees practice direct seeding by hand and by a six-row or eight-row direct seeder with pregerminated and dry seeds. Check the quality of their work after seeding has been done.

EVALUATION

1) What is the most significant advantage of direct seeding?
2) How many methods of direct seeding are there?
3) In what way is direct drilling in puddled soil more preferable than broadcast on puddled soil?
4) In "Drilling in granulated soil," why should the field not be irrigated before seeds are sown?
5) Why should seeds intended for drilling in dry soil not be pregerminated?
6) In "Drilling in puddled soil," what soil condition must be obtained before sowing? Why?
7) In "Broadcast in water," why is it not recommended to sow the seeds when the water is too muddy?

I. FERTILIZERS

1. FERTILIZERS: DEFINITIONS AND CHARACTERISTICS

Objectives: To be able to identify various forms and sources of fertilizers; to know their respective nutrient concentrations; and to list the residual effects of various fertilizers when applied to the soil.

Teaching aids: Samples of fertilizer materials
Table 1

INTRODUCTION

Crops require several plant nutrients in sufficient amounts to give the maximum economic return. The ones required in large amounts are called major elements: nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, carbon, hydrogen, and oxygen. Other plant foods, although equally important, are needed only in small amounts, and are therefore called minor or trace elements: iron, manganese, copper, zinc, boron, molybdenum, chlorine, and silica. Most are obtained from the soil, water, or air, but sometimes the major elements, nitrogen, phosphorus, and potassium, are not available in sufficient amounts for good yields. The soils must therefore be replenished with these elements in the form of fertilizers. Farmers should be able to identify the right kind of fertilizer to apply in their fields.

PRESENTATION

A. *Definitions of fertilizers*

Single-element fertilizers contain only one fertilizer element.

Examples: ammonium sulfate (N)
urea (N)
superphosphate (P_2O_5)
muriate of potash (K_2O)

Incomplete fertilizers contain two fertilizer elements.

Example: ammonium phosphate ($N + P_2O_5$)

Complete fertilizers contain all three of the major fertilizer elements: nitrogen (N), phosphate (P_2O_5), and potash (K_2O) as in a 14-14-14 mixture.

B. *Analysis or grade of fertilizers*

The composition of a fertilizer element in a fertilizer formulation is expressed in percent. If ammonium sulfate has an analysis of 21 percent N, it means that in every 100 kg of ammonium sulfate there is 21 kg of available nitrogen. The analysis of most fertilizer materials available commercially is expressed by a numbering system showing the percentage of composition of each element in the order N-P-K. These numbers are printed on the label of each fertilizer container.

Examples:

a) The complete fertilizer 14-14-14 has 14 percent each of nitrogen, phosphate and available potash. These add up to 42 percent of plant nutrients. The remaining 58 percent represents materials called carriers of the three elements N-P-K. They may or may not contribute to plant nutrition.

b) For monoammonium phosphate, the analysis is 11-45-0. This means that 11 percent is nitrogen, 45 percent is phosphate (P_2O_5) and there is no potash.

c) The analysis of urea is 45-0-0. It means nitrogen is the only plant nutrient available, and the nitrogen composition is 45 percent.

C. *Characteristics of fertilizer materials*

Each fertilizer material has its own analysis and residual effect in the soil to which it is applied. Table 1 shows the analysis of various fertilizer materials and their corresponding equivalent acidity (acid-forming residue effect) or basicity (basic residual effect).

APPLICATION

Distribute Table 1 and discuss it.

a) Using the numbering system showing the percentage of composition of each element in the order N-P-K, ask the trainees to give the analysis of fertilizer materials listed in Table 1.

b) Distinguish solophos (single superphosphate) from triphos (triple superphosphate) by composition of P_2O_5 and by chemical formula.

c) Differentiate monoammonium phosphate from diammonium phosphate by composition of N and P_2O_5 and by chemical formula.

d) Explain the residual effects of fertilizer materials.

EVALUATION

1) What is a single-element fertilizer?
2) What is a complete fertilizer?
3) What is the analysis of a fertilizer:
4) How do commercial fertilizer manufacturers label their fertilizer products?
5) Cite three examples of acid-forming fertilizers.

Table 1. Characteristics of fertilizer materials for use in flooded rice soils

Fertilizer	N %	P_2O_5 %	K_2O %	Ca %	S %	Equivalent acidity or basicity in kg of calcium carbonate per 100 kg of fertilizer material	
						Acid	Basic
NITROGEN							
Ammonium sulfate							
$(NH_4)_2SO_4$	20-21				24	110	
Urea $CO(NH_2)2$	45-46					71	
Ammonium chloride							
NH_4Cl	25					140	
Ammonium nitrate							
NH_4NO_3	33.5					62	
Anhydrous ammonia							
NH_3	82					145	
Calcium nitrate							
$Ca(NO_3)_2$	15.5			21			20
Calcium cyanamide							
$CaCN_2$	20-22			37			63
Calcium ammonium nitrate							
$Ca(NO_3)_2$	11.6			8.8		9	
NH_4NO_3	5.4						
PHOSPHORUS							
Superphosphate single or ordinary, or solophos							
$CaSO_4 + Ca(H_2PO_4)_2 \cdot H_2O$		20		18-21	12		
Superphosphate double or triple or triphos							
$Ca(H_2PO_4)_2 \cdot H_2O$		45-50		12-14	10		
POTASSIUM							
Potassium chloride (muriate of potash)							
KCl			60	0.3		neutral	
Potassium sulfate							
K_2SO_4			53		18	neutral	
N & P							
Monoammonium phosphate							
$NH_4H_2PO_4$	11	45		1.4	2.6	18	
Diammonium phosphate							
$(NH_4)_2HPO_4$	21	53				75	
N & P & K							
12-24-12	12	24	12				
14-14-14 etc.	14	14	14				

2. FERTILIZER CALCULATIONS

Objective: To be able to compute the correct amount of fertilizer material to be applied to a given area at the recommended rate.

Materials: Pencil and bond paper

Teaching aids: OHP transparency showing a map of farmers' fields having different sizes and shapes
Tables 1, 2 and 3

INTRODUCTION

Like the numbering system for expressing an analysis of fertilizer, fertilizer recommendations are given in kilograms of nutrient elements per hectare in the order N-P-K. If only nitrogen is needed, the rate is given in kilograms of nitrogen per hectare. When given the recommended rate of fertilizer and the fertilizer materials he can buy locally, the farmer must be able to weigh the exact amount of the appropriate fertilizer materials to apply to the individual plots of his farm. To achieve this, he must be able to calculate the amount of fertilizer required for each plot.

PRESENTATION

After determining the nutrient status of the soil by soil analysis or fertilizer trials, the farmer is in a position to determine the kinds and quantities of the various fertilizer elements required. The following procedures are recommended for calculating the various amounts of fertilizer materials required.

Operation 1. *Calculating for a single-element fertilizer*

Steps	Key points
1 Decide what fertilizer material to use	Select a fertilizer material that is: a) available locally; b) least expensive per unit of needed plant nutrients; c) suited to the soil conditions (slightly acidic soil requires fertilizer with less residual acid effect); and d) stored and applied with available equipment.
2 List necessary data	The data needed are: a) the recommended rate R of application of the single element (kg/ha). b) the analysis c of the selected single-element fertilizer material (%); and c) area A to be fertilized (sq m).
3 Compute the amount of fertilizer material required per hectare	Divide rate R by the analysis c $\text{Rate (kg/ha)} \div \frac{\text{Analysis (\%)}}{100}$ or $\frac{R}{\frac{c}{100}} = \frac{100\,R}{c}$ (kg/ha)
4 Compute the amount of fertilizer material required per square meter	Divide the required amount per hectare by 10,000 $\frac{100\,R}{c} \div 10{,}000$ or $\frac{100\,R}{10{,}000\,c} = \frac{R}{100\,c}$ (kg/sq m)

5 Compute the amount of fertilizer material required for area concerned	Multiply the required amount per square meter by the number of square meters of the area $\frac{R}{100\ c}$ x Area (sq m) or $\frac{\text{Rate (kg/ha)} \times \text{Area (sq m)}}{100 \times \text{Analysis (\%)}}$ = kg fertilizer required by the area

(The instructor will proceed to the application of Task 1 before discussing Task 2)

Operation 2. *Calculations of fertilizer materials required by recommendations involving more than a single nutrient element*

Steps	Key points
1 Decide what combination of fertilizer materials to use	The combined fertilizer materials should: a) contain all the elements required; b) be available locally; c) be least expensive; and d) be suited to the soil condition (slightly acid soil requires fertilizer with less residual acid effect). For example a recommended rate of 80-30-30 can be made up from the complete fertilizer 14-14-14 and urea, or from urea, triphos and muriate of potash.
2 Compute the amount of each fertilizer material to satisfy the recommended rate	a) If you select fertilizer materials containing only single elements, proceed to Operation 2A. b) If you select fertilizer material containing an incomplete or a complete fertilizer, proceed to Operation 2B.

Operation 2A. *Calculation of fertilizer materials required by recommendations involving more than a single element. Case 1: Combination of single-element fertilizer materials*

Steps	Key points
1 List the given data and the analysis of selected single-element fertilizer materials	Given data: a) the area (A) of application (sq m) b) the recommended rates of fertilizer application (R_N-R_p-R_K) with: R_N (kg N/ha) R_p (kg P_2O_5/ha) R_K (kg K_2O/ha) In the example above urea, triphos, and muriate of potash are selected, therefore: urea 45% N triphos 50% P_2O_5 muriate of potash 60% K_2O
2 Compute the individual amount of each single-element fertilizer material required for the area concerned	Refer to Operation 1. Compute first the amount of urea required; then those of triphos and muriate of potash to satisfy the recommendation of 80-30-30 in the example above.

(The instructor will proceed to application of Operation 2A before discussing Operation 2B)

Operation 2B. *Calculation of fertilizer materials required by recommendations involving more than a single element. Case 2: Combination of single-element and incomplete or complete fertilizer materials*

Steps	Key points
1 List the given data and the analysis of selected fertilizer materials	a) Given data: Area and recommended rate. b) For example if 14-14-14 and urea are used to satisfy the recommendation 80-30-30, list down: 14-14-14: 14% P_2O_5 and 14% K_2O; urea 45%. c) or if ammonium sulfate, monoammonium phosphate and muriate of potash are selected, list ammonium sulfate: 21% N monoammonium phosphate: 11% N, 45% P_2O_5 muriate of potash: 60% K_2O
2 Compute the amount of fertilizer material that satisfies the element required in the smallest quantity	In the recommended rate 80-30-30, phosphorus and potassium are least required. They must be computed first. If the combination 14-14-14 and urea is used, 30 kg of N, 30 kg of P_2O_5 and 30 kg of K_2O are supplied by the 14-14-14 $\frac{30 \times 100}{14} = 214.3$ kg/ha of 14-14-14
3 Compute the remaining amount of the element required	In the example above, 214.3 kg of 14-14-14 gives 30-30-30. Subtract this from the rate 80-30-30 80-30-30 - 30-30-30 50- 0- 0 or 50 kg of N is yet to be supplied by urea.
4 Compute the amount of fertilizer material that satisfies the remaining amount of the element required	Divide the remaining amount by the analysis of the fertilizer material. If 50 kg of N is supplied by urea, the weight of urea is obtained $\frac{50}{45} \times 100 = 111.1$ kg/ha of urea

(The instructor will proceed to the application of Task 2B)

APPLICATION

Task 1

1) Calculate how much ammonium sulfate is needed to supply 100 kg/ha of nitrogen to an area of 2,500 sq m. Solution:

Step 1. Fertilizer material to use: ammonium sulfate

Step 2. Necessary data:

Rate R = 100 kg N/ha

Analysis of ammonium sulfate c = 20%

Area A = 2,500 sq m

Step 3. Required amount per hectare =

$$\frac{100\,R}{c} = \frac{100 \times 100}{20} = 500 \text{ kg/ha}$$

Step 4. Amount required per square meter

$$\frac{\text{kg} \cdot \text{Fertilizer material per ha}}{10{,}000 \text{ sq m per ha}} = \frac{500}{10{,}000} = 0.05$$

$$= 0.05 \text{ kg/sq m}$$

Step 5. Amount required per area of 2,500 sq m

$0.05 \times 2{,}500 = 125$ kg

2) To demonstrate the applicability of Step 4, the instructor will show the OHP transparency and explain that if the entire farm receives the same rate of fertilizer, the operator can quickly calculate the amount of fertilizer required for each area by multiplying the variable area by the constant value of the amount required per square meter.

Task 2

Suppose a certain soil requires a fertilizer rate of 120-40-0. List the possible combinations of the following materials which might be used to make up the recommended rate: urea, ammonium sulfate, solophos, triphos, 16-20-0.

(The instructor may want to give another example, using an application requiring three elements, e.g. rate of 100-30-30.)

Task 2A

If urea and triphos were selected for instance, show how much of each material is needed to fertilize a plot of 625 sq m.

Solution:

Step 1. Listing

Area	:	625 sq m
Rate of application:		120 kg N/ha
		40 kg P_2O_5/ha
Urea	:	45% N
Triphos	:	50% P_2O_5

Step 2. Amount of urea required:

$$\frac{120 \times 625}{100 \times 45} = 16.7 \text{ kg urea}$$

Step 3. Amount of triphos required:

$$\frac{40 \times 625}{100 \times 50} = 5 \text{ kg triphos}$$

(Another example using a three-element recommendation may be given.)

Task 2B

If urea and monoammonium phosphate were selected, show how much of each material is needed to fertilize the same plot of 625 sq m.

Solution:

Step 1. Listing

Area = 625 sq m

Rate of application = 120 kg N/ha

40 kg P_2O_5/ha

Urea = 45% N

Monoammonium phosphate = 11% N and 45% P_2O_5

Step 2. The element which has the smaller rate is P_2O_5. It is supplied by monoammonium phosphate. The amount of monoammonium phosphate needed is

$$\frac{40}{45} \times 100 = 88.9 \text{ kg/ha}$$

or

$$\frac{40 \times 625}{100 \times 45} = 5.56 \text{ kg for the area}$$

Step 3. 88.9 kg of monoammonium phosphate contains

$$\frac{11 \times 88.9}{100} = 9.8 \text{ kg N}$$

Remaining amount of N to complete the rate is 120 - 9.8 = 110.2 kg of N supplied by urea.

Step 4. Required amount of urea

$$\frac{110.2 \times 100}{45} = 244.9 \text{ kg/ha urea}$$

or

$$\frac{110.2 \times 625}{100 \times 45} = 15.3 \text{ kg urea/ha for the area}$$

(Another example of a three-element recommendation may be given.)

Use of conversion tables

(Distribute tables 1, 2, and 3 and discuss them.)

The amount of several common fertilizer materials corresponding to any rate of application of N, P_2O_5, and K_2O, between 10 and 150 kg/ha can be obtained quickly from the tables. Drill the trainees on these tables.

EVALUATION

1) A plot of 300 sq m is to be fertilized with nitrogen at a rate of 100 kg N/ha How much ammonium sulfate is needed?

2) A 14-hectare farm requires a fertilizer application of 80-30-30. If urea and 12-12-12 complete fertilizer are available, calculate the total weight of each material needed by the farm. How many bags of each material will be purchased if each bag weighs 50 kg?

3) An experimental plot of 1,000 sq m will be fertilized at the rate of 100-40-40. Given: urea 45% N, 16-20-0 and muriate of potash 60% K_2O. How much of each material is needed?

Table 1. Conversion of pure nutrients to quantity of various nitrogen fertilizers.

Rate of N application (kg/ha)	Ammonium sulfate (20% N)	Nitrogen fertilizer (kg/ha)			
		Urea (45% N)	Ammonium chloride (26% N)	Ammonia (25% N)	Aqua anhydrous ammonia (82% N)
10	50	22	38	40	12
20	100	44	77	80	24
30	150	67	115	120	37
40	200	89	154	160	49
50	200	111	192	200	61
60	300	133	231	240	73
70	350	156	269	280	85
80	400	178	308	320	98
90	450	200	346	360	110
100	500	222	385	400	122
110	550	244	423	440	134
120	600	267	462	480	146
130	650	289	500	520	159
140	700	311	638	560	171
150	750	333	577	600	183

The N (nitrogen) figures should be multiplied by 5.0 for ammonium sulfate, 2.2 for urea, 3.8 for ammonium chloride, 4.0 for aqua ammonia, 1.2 for anhydrous ammonia.

Table 2. Conversion of pure nutrients to quantity of various phosphorus fertilizers.

Rate of P_2O_5 application (kg/ha)	Phosphorus fertilizer (kg/ha)	
	Ordinary superphosphate (20% P_2O_5)	Triple superphosphate (45% P_2O_5)
10	50	22
20	100	44
30	150	67
40	200	89
50	250	111
60	300	133
70	350	156
80	400	178
90	450	200
100	500	222
110	550	244
120	600	267
130	650	289
140	700	311
150	750	333

The P_2O_5 (phosphorus) figures should be multiplied by 5.0 for ordinary superphosphate, 2.2 for triple superphosphate.

Table 3. Conversion of pure nutrients to quantity of various potassium fertilizers.

Rate of K_2O application (kg/ha)	Phosphorus fertilizer (kg/ha)	
	Muriate of potash (60% K_2O)	Sulfate of potash (50% K_2O)
10	17	20
20	33	40
30	50	60
40	67	80
50	83	100
60	100	120
70	117	140
80	133	160
90	150	180
100	167	200
110	183	220
120	200	240
130	217	260
140	233	280
150	250	300

The K_2O (potassium) figures should be multiplied by 1.7 for muriate of potash, 2.0 for sulfate of potash.

3. MIXING FERTILIZERS

Objectives: To be able to mix two or more fertilizer materials, and to be able to recognize the compatibility of the fertilizer materials.

Materials: Each group of trainees will need:

5 kg ammonium sulfate, 21% N
1.5 kg diammonium phosphate, 21% N + 54% P_2O_5
1 kg muriate of potash, 60% K_2O

1 scale, 10 - kg capacity
1 sheet of paper, size 1 x 1 m
Pencil and bond paper

Teaching aids: Figure 1

INTRODUCTION

When a fertilizer treatment requires material containing more than one element, it is likely that an incomplete or a complete fertilizer will be used. If necessary, two or more single-element fertilizer materials may be used. These materials may be weighed and applied separately, or they may be blended and the mixture applied to the soil. The latter procedure is more convenient and facilitates field application, especially in large mechanized farms. However, not all fertilizer materials can be mixed. For example, strongly basic materials, such as lime, should not be mixed with urea or the nitrogen may be lost as ammonia. The trainees must be able to identify compatible fertilizer materials, and to mix fertilizers.

PRESENTATION

A. *Compatibility of fertilizer materials*

Distribute fig. 1 and discuss it.

If you need to fertilize a soil with nitrogen and phosphorus, can you mix ammonium sulfate with rock phosphate? Can you mix urea with superphosphate? Figure 1 shows how, if such mixtures are made, the individual constituents would react with one another, making one of the nutrients useless.

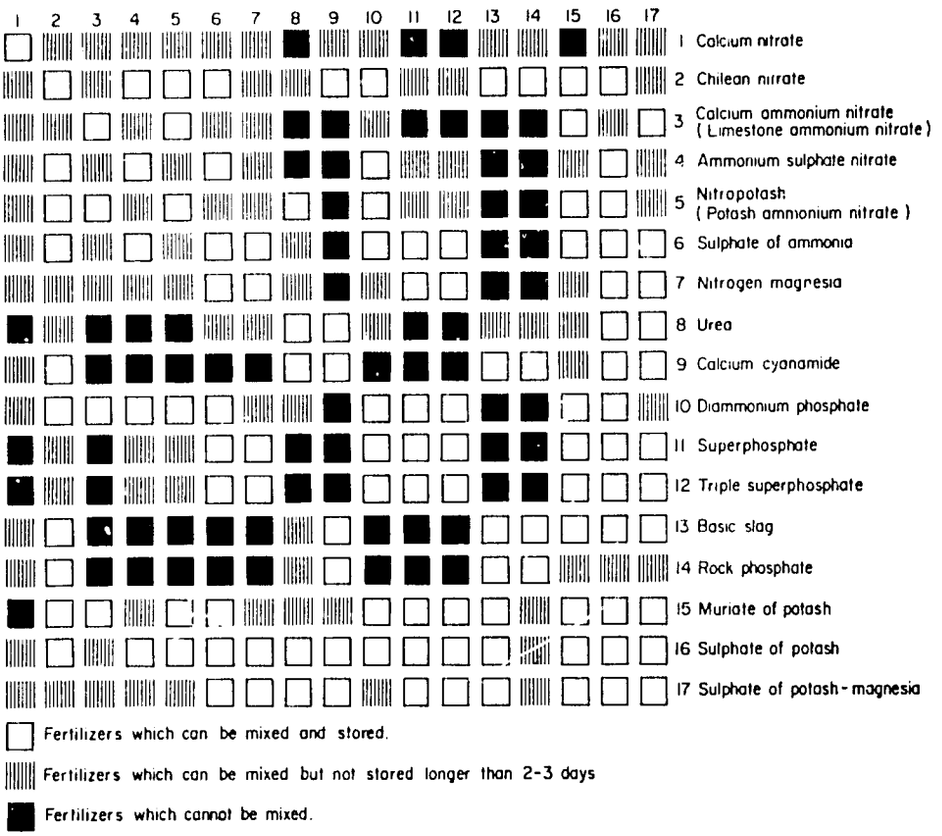


Fig. 1. Guide for mixing and storing fertilizers. (Reproduced from Handbook of Manures and Fertilizers by permission of Indian Council of Agricultural Research, Krishi Bhavan, New Delhi, India.)

B. *Mixing fertilizers*

Steps	Key points
1 Determine the feasibility of the mixture	a) Consult fig. 1 for compatibility. b) Do not try to mix fertilizers of greatly different particle size as these tend to separate during handling.
2 Compute the amount of each fertilizer material	Refer to lesson on Fertilizer Calculations, Operation 1. Double-check the calculations.
3 Weigh the fertilizer materials	a) If mixture weighs more than 75 kg, prepare it in two or more batches, as it is difficult to achieve uniform blending of a large quantity. b) Weigh to the nearest 0.1 kg.
4 Mix the fertilizer materials	a) Spread out the materials in thin layers, one above the other, over a smooth, clean surface. b) Two men with shovels take positions facing one another on either side of the fertilizers. c) Each simultaneously raises a shovel full of materials and pours the contents to meet the contents of the other's shovel. This mixing action is continued, and the two men occasionally change their positions, until it is impossible to distinguish streaks of individual materials in the mixture. d) For amounts less than 10 kg, one man can easily accomplish the above mixing procedure with his hands, or by shaking the materials in a bag.

APPLICATION

Have each group of trainees formulate a 60-30-30 mixture of ammonium sulfate, diammonium phosphate, and muriate of potash sufficient to apply to 200 sq m.

(Give the trainees the analysis of the materials and ask them to compute the amount of each to make up the required mixture). Here are the solutions:

Step 1.

Ammonium sulfate	21-0-0
Diammonium phosphate	21-54-0
Muriate of potash	0-0-60
Rate of application	60-30-30
Area	200 sq m

Step 2. Weight of diammonium phosphate to supply 30 kg P_2O_5/ha

$$\frac{30 \times 100}{54} = 55.5 \text{ kg of diammonium phosphate}$$

Step 3. That amount of diammonium phosphate also gives

$$\frac{21 \times 55.5}{100} = 11.6 \text{ kg N/ha}$$

thus leaving 60 — 11.6 = 48.4 kg N/ha to be supplied by ammonium sulfate

$$\frac{48.4 \times 100}{21} = 230.5 \text{ kg of ammonium sulfate}$$

Step 4. Weight of muriate of potash to supply 30 kg of K_2O

$$\frac{30 \times 100}{60} = 50.0 \text{ kg muriate of potash}$$

Step 5. Amounts required by 200 sq m

a) Ammonium sulfate

$$\frac{230.5 \times 200}{10{,}000} = 4.6 \text{ kg}$$

b) Diammonium phosphate

$$\frac{55.5 \times 200}{10{,}000} = 1.1 \text{ kg}$$

c) Muriate of potash

$$\frac{50.0 \times 200}{10{,}000} = 1.0 \text{ kg}$$

Step 6. Weigh required amounts and perform the mixing procedure.

EVALUATION

Consider the performance satisfactory if the trainees obtain the correct amounts shown above and produce a uniform mixture.

1) Can you mix any two or more different fertilizers at will? Why?
2) Using figure 1, give three possible fertilizer mixtures.
3) What is the difficulty in mixing fertilizer materials of greatly different particle sizes?

4. APPLYING FERTILIZERS

Objective: To be able to fertilize a rice crop given the recommended rate.

Materials:
- A plot ready for transplanting
- A rice crop at panicle initiation stage
- 1 pocket knife, or razor blade
- 1 hand lens, magnification 10x
- Fertilizers, enough to apply to 2 plots
- 1 scale, 10-kg capacity

Teaching aids: OHP transparencies showing figures 1, 2 and 3

INTRODUCTION

Applying the correct amount of fertilizer to the proper place in the soil at the time when the crop needs it most is one of the keys to successful rice production. Improved rice varieties need nitrogen, phosphorus, and potassium in large amounts during their early stages of growth. If fertilizers, particularly nitrogen, are not applied properly to the paddy, maximum economic returns may not be achieved.

PRESENTATION

Because the water supply in most farms is not controlled, generally the nitrogen fertilizer should be applied in two split doses: half incorporated before planting, the other half topdressed 5 to 7 days before panicle initiation. On coarse soils, the nitrogen fertilizer should be applied in three doses: one third basally incorporated, another third applied 20 to 30 days after transplanting (depending upon the growth duration of the rice variety used), and the remaining third applied at panicle initiation. All applied phosphorus and potassium should be incorporated into the soil before planting.

Operation 1. *Basal application of fertilizers*

Basal application of fertilizer should be done before the final harrowing.

Steps	Key points
1 Compute the amount of fertilizer to apply	a) Refer to lesson on Fertilizer calculations. b) In a split application, first calculate the amount of nitrogen for each application.
2 Weigh out the computed amount of fertilizer	a) For small research plots weigh to the nearest gram. For commercial application weighing to the nearest kilogram is satisfactory. b) Label individual containers properly.
3 Check the paddy	Keep water level at 2 cm or below. Fertilizer materials tend to float toward the sides of levees during incorporation.
4 Broadcast the fertilizer	Refer to lesson on Broadcasting granular materials.
5 Incorporate the fertilizer into the soil	a) Do the last harrowing thoroughly. b) If it is not possible to pass the harrow (in laid-out plots for instance), use a wooden plank or hand rake to work the soil.
6 Keep the soil wet	a) If transplanting is not done immediately, flood the paddy to 2 cm. b) Never let the soil dry until it cracks as this causes loss of nitrogen when the soil is reflooded.

Operation 2. *Additional application of nitrogen fertilizer*

A rice crop may need an additional application of nitrogen during the later growth stages. If additional nitrogen is required, it is usually topdressed at panicle initiation.

Operation 2A. *How to decide whether to topdress nitrogen fertilizer*

Steps	Key points
1 Count the number of tillers per square meter	a) Count from the third row to the border row. Count the number of hills per sq m as shown in Fig. 1 and 2. b) Most improved rice varieties that are sufficiently fertilized should have at least 350 tillers/sq m.
2 Observe leaf color	Yellowing of entire leaf blades indicates that nitrogen is not sufficient.
3 Count the leaves per tiller	a) If nitrogen is sufficient, each tiller should have four leaves. b) If most tillers have four leaves, see whether there is too much shading. This will help you decide on a wider or a closer spacing at next planting using the same fertilizer recommendation.

Operation 2B. *How to determine the visible panicle primordium*

Steps	Key points
1 Cut off a tiller	a) Do this daily starting at 50 to 70 days *after sowing* until panicle initiation. b) Cut tiller close to the base.
2 Dissect the stem	With a sharp pocket knife or razor blade, carefully slice the stem lengthwise at the center from the base up.
3 Look for the panicle primordium	The beginning of the panicle appears as a small white growth at the top of the uppermost node (see Fig. 3). Use a hand lens for observing the panicle primordium.

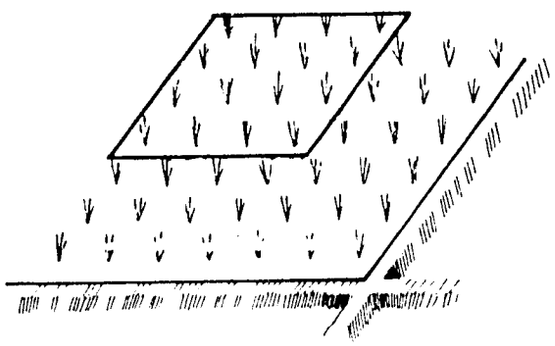


Fig. 1. Number of hills per square meter from which the tillers are counted when spacing is 25 x 25 cm.

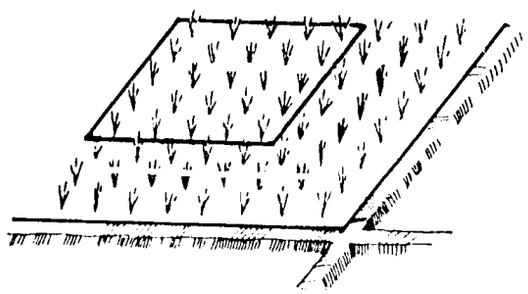


Fig. 2. Number of hills per square meter from which the tillers are counted when spacing is 20 x 20 cm.

Operation 2C. *Topdressing of nitrogen fertilizer*

Steps	Key points
1 Determine panicle initiation	See Operation 2B.
2 Decide whether to topdress	See Operation 2A.
3 Calculate the amount of fertilizer required	Base calculation on the remainder of the nitrogen recommended. Refer to lesson on fertilizer calculations.
4 Broadcast the fertilizer	Refer to lesson on broadcasting granular materials. Do not broadcast fertilizer if plant leaves are wet.
5 Incorporate the fertilizer into the mud	If possible, work in the ammonium form of fertilizer by hand or with a rotary weeder. This should be done by on topdress ammonium at 25 to 30 days after transplanting.

APPLICATION

1) Have the trainees apply basal fertilizer to a prepared paddy.
2) Take the trainees to a field where the rice crop is about 50 to 70 days old. Have each group of trainees count the number of tillers per square meter.
3) Have each trainee practice the determination of panicle initiation.
4) Have each trainee decide whether or not to topdress nitrogen fertilizer.

EVALUATION

1) In what situation do you split the application of nitrogen fertilizer?
2) What are the appropriate times to apply fertilizer to rice in general?
3) What is basal application?
4) Why must basal application of fertilizer be made before the last harrowing?
5) Cite two criteria for determining whether or not to topdress nitrogen at panicle initiation stage.
6) Where do you find the beginning growth of the panicle on the dissected stem?

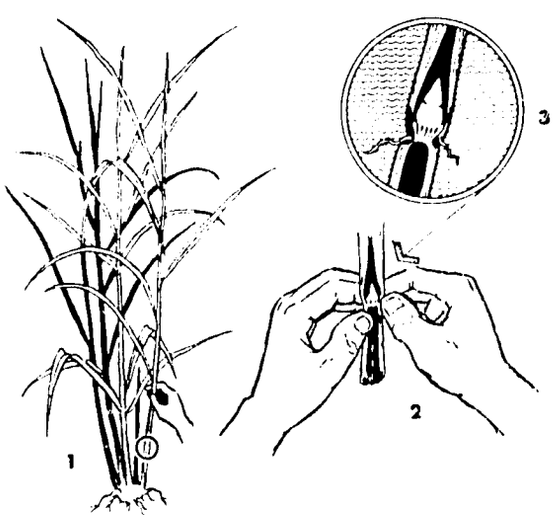


Fig. 3. Dissecting a stem to determine the visible panicle primordium

5. STORING FERTILIZER MATERIALS

Objective: To learn how to store fertilizer materials, and to observe storage precautions.

Materials: 10 (or more) 50-kg bags fertilizer (any kind)
1 wooden pallet, 30 x 100 cm, for every eight bags of fertilizer (Fig. 1)

Teaching aids: A broken bag of fertilizer showing caking of the granules
Slides showing an actual storage area

INTRODUCTION

Even crop growth depends partly on the quality of fertilizer and its uniform distribution in the soil, both of which are affected by the way the farmer stores his fertilizer materials. Therefore the farmer must store fertilizer properly observing the precautions for storage.

PRESENTATION

Storage is not a problem to a small farmer who buys only a few bags of fertilizer and uses them immediately. However when more than 5 bags are to be stored for sometime, they should be stacked.

Steps	Key points
1 Select a storage area	a) The place must be ventilated and dry. b) It must be protected from rain.
2 Place wooden pallets	a) Place one pallet under each stack. b) Pallets keep bags from touching the ground.
3 Stack the fertilizer bags	a) Place the bags on top of each other on the pallet (Fig. 2). b) Do not put more than eight bags in a stack. The pressure on the bottom bag tends to cause the material to cake. c) Stack only unbroken bags, and arrange the stacks closely to minimize air space between stacks.

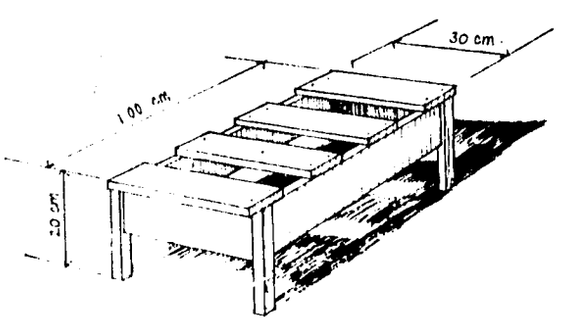


Fig. 1. A wooden pallet.

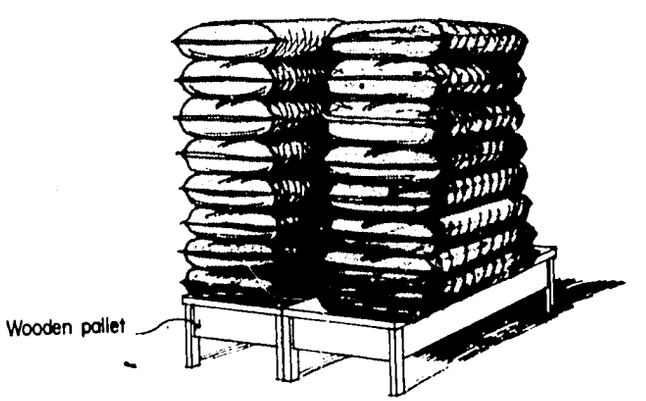


Fig. 2. Stacked fertilizer bags. Each stack should not contain more than eight bags.

Precautions concerning fertilizer storage

1) Do not store fertilizer with insecticides or herbicides.
2) Do not store fertilizer with gasoline, oil, flammable liquid, acids, sulfur, or explosives.
3) Do not smoke in storage areas.
4) Store the fertilizer in moisture-proof containers or bags to keep it from absorbing moisture from the air. Close tightly a bag that has been opened.
5) Keep broken bags separate from unbroken bags because fertilizer in broken bags absorbs moisture and cakes quickly.
6) Always store ammonia under pressure.

APPLICATION

1) Emphasize the importance of having fertilizer container tightly closed. Show the content of a broken bag of fertilizer.
2) Ask the trainees to stack fertilizer bags in a storage area.

EVALUATION

1) Describe how to stack 20 bags of fertilizer.
2) Why should you not let fertilizer touch the floor?
3) What will happen when more than eight bags of fertilizers are put on a stack?
4) Cite four precautions concerning fertilizer storage.
5) Why is it preferable to arrange the stacks closely?

5. APPLYING AGRICULTURAL CHEMICALS

1. BROADCASTING GRANULAR MATERIALS[1/]

Objective : To be able to apply by hand a given amount of granular herbicide, insecticide, or fertilizer uniformly to a specified area.

Materials: Each group of trainees will need:

5 kg dry sand	Fertilizer
Herbicide	2 buckets
Insecticide	2 plastic bags

INTRODUCTION

Fertilizers, insecticides, and herbicides are manufactured in liquid and solid forms. The granular form has become increasingly popular because it is easier to apply. Although convenient to apply to the ricefield, it should be broadcast evenly so that each rice plant will get an equal amount of the chemicals to insure uniform growth and protection.

In broadcasting granular materials, or dusts, you must know the amount (weight or volume) of materials you should spread per unit area.

PRESENTATION

Steps	Key points
1 Measure area to which granular materials will be applied	Area should be in square meters.
2 Compute the exact amount of granular materials needed	Refer to lessons on computation of herbicide, insecticide, or fertilizer. a) The rate of application. b) The amount of active ingredient in the material. c) The area to be treated.
3 Weigh the exact amount of granular materials computed	Use a plastic bag to hold the materials.
4 Mark the area to be treated	Use bamboo stakes.

[1/] Partly adapted from S.K. De Datta, "Fertilizers and soil amendments for tropical rice." *In* Rice production manual (Revised 1970 edition), p. 126 The University of the Philippines, Laguna, Philippines.

5 Place the granular materials in a container	The container (bucket) must be convenient to carry.
6 Broadcast the granular materials	a) Pick up a handful of granules and throw the granules in an arc with a horizontal movement of the hand with the fingers slightly separated. The width covered by one throw is generally 3 meters. b) Use only one stroke for each handful. c) Move forward at a constant speed as you throw. d) When your hand is empty take another handful of granules. e) Broadcast the materials as evenly as possible. It may be easier to broadcast one half of the amount over the entire area first, and the remainder at right angles to the first application, applying additional amounts to areas which did not receive enough the first time. f) If the wind is blowing, broadcast crosswind while keeping your hand low. CAUTION: Do not apply granular materials when the leaves of plants are wet. g) Never broadcast a chemical against the wind.
7 Wash hands and container thoroughly	

APPLICATION

1) Have each trainee practice with dry sand:
   a) Measure and stake an area 100 sq m (10 x 10 m or 5 x 20 m).
   b) Weigh 0.25 kg and 0.50 kg of sand separately.
   c) Broadcast first the 0.25 kg sand over the entire 100 sq m area as shown in Step 6 above. Note your speed of walking. Upon accomplishing this, you will have applied 25 kg of granular materials per hectare.
   d) Broadcast the 0.50 kg sand over the entire area. Notice how much you have to reduce your walking speed in order to distribute all 0.50 kg sand evenly. By doing so, you will have applied 50 kg of granular materials per hectare.
2) Give each trainee a chance to broadcast fertilizer, insecticide, and herbicide.

EVALUATION

1) Why is it important to broadcast granular chemicals uniformly over a given area?
2) What happens if granular materials are broadcast when plant leaves are wet?
3) When throwing the granules, why should your hand be kept horizontal?
4) While throwing the granules you must move forward at constant speed. What may happen if you suddenly change your walking speed?
5) How would you broadcast when it is windy?
6) What is the last step in broadcasting granular materials?

2. SPRAYERS: PARTS AND THEIR FUNCTIONS

Objectives: To be able to identify the parts of a compressed-air sprayer and of a knapsack sprayer; and to describe the functions of these parts.

Materials: Each group of trainees will need:

1 compressed-air sprayer
1 knapsack sprayer
1 flat hydraulic pressure nozzle
1 solid cone hydraulic pressure nozzle
1 hollow cone hydraulic pressure nozzle

Teaching aids: Overhead projector transparencies showing a) cut-away drawings of compressed-air and knapsack sprayers, and b) the components of flat, hollow, and solid cone nozzles

INTRODUCTION

The introduction of granular pesticide (insecticide, fungicide or herbicide) has simplified pest control operations of most farmers. It has not, however, totally eliminated the need for foliar sprays, especially when a curative control measure is needed, as in an outbreak of hoppers, rice bugs, blast, sheath blight, etc. Just as a good carpenter must own and use good tools to work efficiently, the good rice farmer must have and use good sprayers for pest control. He must know how to choose the equipment properly to attain best results.

Sprayers vary from the hand-pumped intermittent-type household sprayer with a tank capacity of as little as 200 cc, to large, hydraulic, engine-powered sprayers with a tank capacity of 400 liters or more. For pest control in rice, hand-operated knapsack sprayers are very widely used and are becoming an essential item for most good farmers. Of these sprayers, the compressed-air type and the knapsack type are most popular.

This lesson is designed to illustrate the various parts of such sprayers and to explain their respective functions.

PRESENTATION

A. *Essential parts of hand-operated hydraulic energy sprayers*

Generally a hand-operated hydraulic energy sprayer is composed of a reservoir system, a pump assembly, and a delivery assembly.

The reservoir system is a leak-proof storage for spray material. It consists mainly of a tank, a filler cap, and strainer(s) (fig. 1 and 5). The tank, including bottom, sides, top, and removable filler cap, is made of stainless steel, brass, bronze, copper, Monel, or other specified metal. It is fitted with a pressure-type filler cap. A funnel top is provided on some models to make filling easier. The tanks are 3.8 to 22.5 liters (1 to 6 US gallons) in size. All threaded connections and all joints must be leak-proof to withstand a pneumatic pressure of 5.6 kgf/sq cm (80 lbf/sq in).[1/] Most tanks have clear fill marks representing the three-quarters of the total air and liquid capacity of the tank to indicate the maximum liquid charge permitted.

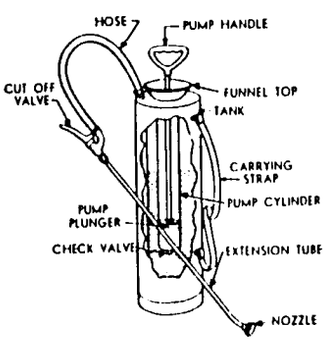


Fig. 1. A compressed air sprayer. (From U. S. Department of Agriculture Home and Garden Bulletin No. 63, "Hand sprayers and dusters.")

Most tanks are provided with one or two strainers as parts of the filler cap assembly to prevent dirt particles from getting into the tank.

The pump assembly. Two kinds of pumps are commonly used for these sprayers: the plunger-type pump and the diaphragm pump. Either type may be situated within the container and draw the liquid directly from the inside, or it may be placed externally on the container and draw liquid from it

1/ Pressures are expressed in kilograms-force per square centimeter (kgf/sq cm) and in pounds-force per square inch (lbf/sq in), in accordance with the recommendations of the International Organization for Standardization.

through a suction tube connected to an outlet placed in the bottom.

a) Plunger-type pump consists of a handle or lever, a cylinder, a plunger, and a check valve (fig. 1). The cylinder should withstand internal and external application of pressure up to 8.5 kgf/sq cm (120 lbf/sq in). It should be easily detachable from the tank. A plunger shaft is attached to the handle or operating lever on one end, and to a cup leather on the other. The cup leather is fitted and travels in the cylinder. The bottom of the cylinder is connected to a check valve which is both liquid and air-tight. It prevents any continuous flow of liquid into the cylinder, and permits passage of air compressed by the plunger.

b) Diaphragm-pump consists of a diaphragm and an air chamber (fig. 5). The air chamber is provided to absorb the pulsation and maintain pressure on the spray liquid between strokes. This feature is common in all knapsack sprayers.

The plunger-type pump normally provides higher outputs than the diaphragm type, while the diaphragm pump often requires less energy for operation and also less maintenance. Furthermore it will withstand wear much better than the plunger-type pump.

The delivery assembly. Generally, a delivery assembly consists of a dip tube, strainers, spray hose, cut-off valve, lance, and nozzle (fig. 1 and 5).

a) Dip tube (or discharge tube). This is a tube connected to the hose and extending inside the tank down to within about 1 cm of the bottom. The liquid under is forced out of the tank through this tube. A dip tube is almost always present in compressed-air sprayers. Many knapsack sprayers do not have this feature, instead the spray material flows through a suction tube incorporated in the pump assembly.

b) Strainers. Two strainers with openings not larger than 0.5 mm in diameter are provided at different points in the discharge line between the entry to the dip tube and the entry end of the cut-off valve. They prevent passage of large particles in the spray to minimize clogging of nozzles.

c) Spray hose. The hose is made of chemical-and oil-resistant rubber or plastic. Its inside diameter is normally 9.5 mm. One end is connected to the tank outlet and the other to the cut-off valve. It is made of strong material, preferably with one or two plies of reinforcement made of cotton yarn, or synthetic fiber, so that it will not burst during the spraying operation.

d) Cut-off valve. Every continuous flow sprayer must have a method of turning on and shutting off

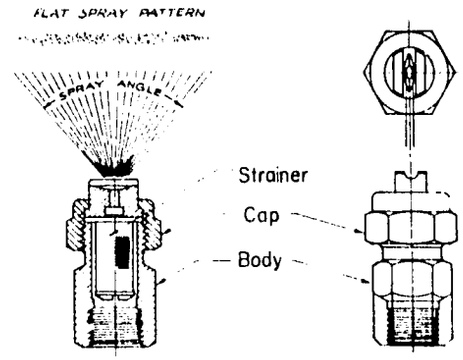


Fig. 2. Schematic drawing of a fan nozzle with a flat spray tip. Note flat spray pattern (Courtesy of Spraying Systems Co., Ill., U. S. A.)

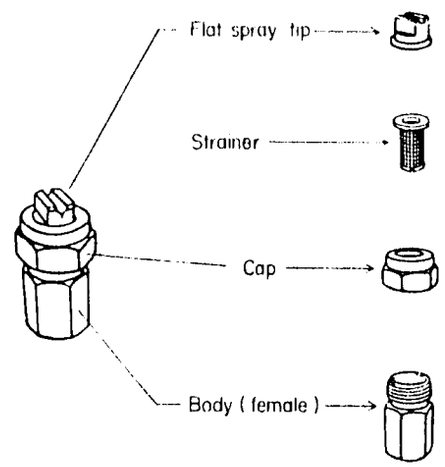


Fig. 3. Parts of a fan nozzle (Teejet). (Reproduced from Agricultural Spray Nozzle Manual by permission of Spraying Systems Co., Bellwood, Illinois, U. S. A.)

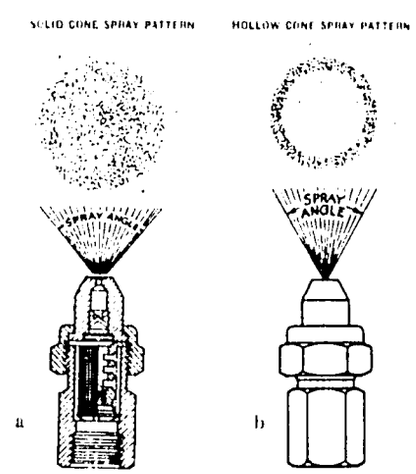


Fig. 4. Schematic drawings of cone nozzles designed to deliver (a) a solid cone and (b) a hollow cone of liquid. (Reproduced from Agricultural Spray Nozzle Manual by permission of Spraying Systems Co., Bellwood, Illinois, U. S. A.)

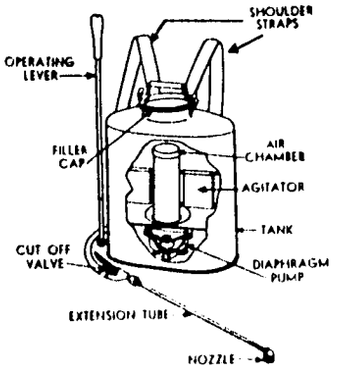


Fig. 5. A knapsack sprayer with a diaphragm pump and a hand lever located at the bottom of the tank. (From U. S. Department of Agriculture Home and Garden Bulletin No. 63, "Handsprayers and dusters.")

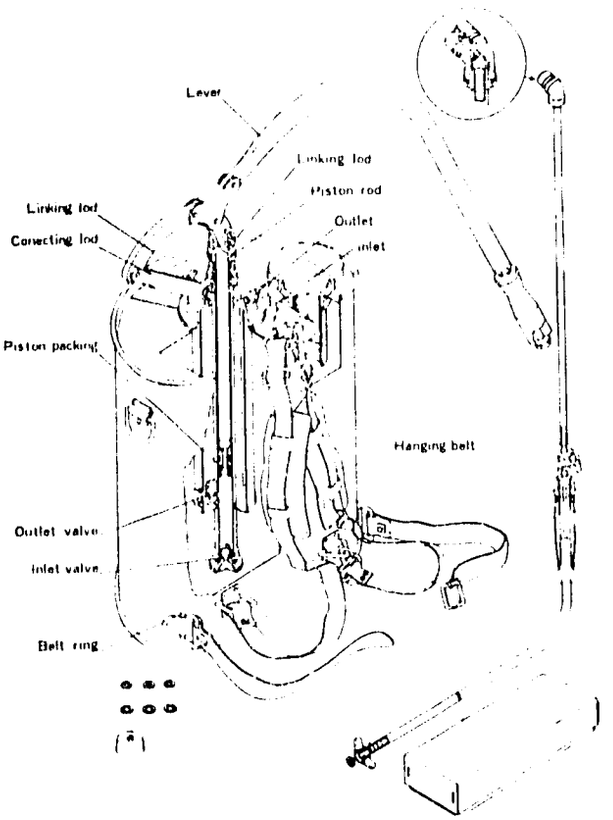


Fig. 6. A knapsack sprayer with plunger-type pump and a hand-lever located on top of the tank. (Reproduced from Maruyama Catalogue by permission of Maruyama Mfg. Co., Ltd., Tokyo, Japan.)

the flow of spray solution to the nozzle. This is accomplished by a valve placed between the hose and the lance. A quick-acting valve is usually preferred because it shuts off immediately when the handle is released and thus prevents leakage from the nozzle.

e) Lance (extension spray tube). The lance is a tube having the same threads and size at both ends so that any number of lances in series, or nozzle, can be connected directly to the cut-off valve housing.

f) Nozzle. Nozzles are designed so that the stream of insecticide can be in the pattern the operator desires. The main function of a nozzle is to obtain uniform distribution of the insecticides whether the sprayed material is distributed on a surface or is dispersed into the air. The different types of nozzles are classified as follows:

i) Hydraulic energy type. The production of droplets is brought about by forcing a liquid under hydraulic pressure through an orifice or orifices. This type is further classified according to the spray patterns as impact (or pin stream), cone (or swivel), and fan types.

ii) Gaseous energy type. This type is sometimes known as twin-fluid nozzles because the production of droplets is achieved by impinging a high velocity air stream (first fluid) on the insecticide stream (second fluid), either inside or outside the body of the nozzle.

iii) Centrifugal energy type. The liquid is fed to a rotating wettable surface where it is spread out by centrifugal force which overcomes the surface tension and viscous force of the liquid. The sheet of liquid thus formed disintegrates into droplets at the edge of the rotating surface or just beyond.

Common patterns used in pest control in rice are the fan, solid cone, and hollow-cone hydraulic energy types.

Fan nozzles (Fig. 2) put out a flat spray which strikes the surface being sprayed in a straight line. It is particularly good in situations where it is necessary to apply an even coating of insecticide on a flat surface. A fan nozzle (Fig. 3) consists of a body (male or female) containing a strainer on top of which sits the orifice tip which is in turn held in place by a cap.

Solid cone nozzles spray a round pattern more or less evenly over the entire pattern (Fig. 4a), while hollow cone nozzles spray a circular pattern with no spray striking the center (Fig. 4b). The body, cap, and strainer are the same as in the fan nozzles. The orifice tip is either a cone or a disc. Cone nozzles are useful when larger capacities are required or when wettable powders are used and sprayed at higher pressures. They are designed to give maximum uniform, complete coverage of insecticides or herbicides, especially in spraying row crops.

B. *Types of hand-operated compression sprayers.*

Compressed-air sprayer (fig. 1). Compressed-air sprayers are simple in design and operation, and are

relatively inexpensive to buy and maintain. They are particularly useful for spot and small-area spraying, e.g. problem spots within a field, weeds along levees, etc.

The essential parts of a compressed-air sprayer are: spray tube, plunger-type pump, dip tube, spray hose, extension spray tube, cut-off valve, and nozzle (fig. 1). The tank usually has a capacity between 7.5 and 15 liters (2 to 4 US gallons). It can withstand pressures up to 3.5 kgf/sq cm (50 lbf/sq in).

Knapsack sprayer (fig. 5). Knapsack sprayers are carried on the back by means of shoulder straps. Like compressed-air sprayers, they are simple in design and operation, and are relatively inexpensive to buy and maintain. The tank is usually shaped to fit comfortably on the shoulders. It has a capacity 15 to 22.5 liters. Two kinds of pumps are used for these sprayers, the diaphragm pump (fig. 5) and the plunger-type pump with cup leather (fig. 6). On sprayers with a capacity of over 3 gal (13.5 liters), where high liquid outputs are required such as boom sprayers, double-action or duplicated pump units of the plunger-type are sometimes provided. All pumps are provided with air chambers.

The pump of a knapsack sprayer is operated by a hand lever which may be situated at the bottom of the sprayer (fig. 5) so that, if used, it extends along the side of the body and under the arm. In other types the lever may be situated at the top of the sprayer (fig. 6) and pass over the shoulder to the front of the body with the handle placed at a convenient height to be grasped by the hand. In any case, the lever is operated by one hand, the other hand being used to control and direct the spray from the lance. In some sprayers, an automatic agitator is provided to maintain a perfectly dispersed spray solution.

A variety of nozzles of the hydraulic type can be used with these sprayers to give hollow or solid cone, fan, jet or adjustable patterns. They are capable of maintaining pressures up to about 4.2 to 5.6 kgf/sq cm (60 to 80 lbf/sq in).

Knapsack sprayers are particularly useful for boom spraying when a series of four nozzles or more are operating at the same time.

APPLICATION

Prefer sprayers readily available in the country. Develop a presentation of these sprayers based on the information above. Dismantle the parts and show them using appropriate key points in the presentation. Ask each trainee to identify the various parts of the sprayers presented to him and to describe the functions of each.

EVALUATION

(Consider the performance of trainees satisfactory when they can correctly identify the parts of a sprayer and describe their functions.)

1) Why is it important to be able to identify the parts of your sprayer and to describe their respective functions?
2) How do you classify compressed-air and knapsack sprayers?
3) What are the three essential assemblies of a hand-operated hydraulic energy sprayer?
4) Describe the reservoir system.
5) What is the function of the strainer at the filler cap?
6) Are spray tanks commonly made of stainless steel? Why?
7) What is the maximum pressure a hydraulic spray tank can withstand?
8) What are the two types of pumps usually employed in hand-operated hydraulic sprayers? How do they differ?
9) Cite one important criterion in considering a sprayer with regard to pump?
10) Give the functions of the air chamber in the pump of a knapsack sprayer.
11) What are the essential components of the delivery system?
12) In some knapsack sprayers, a separate dip tube is omitted. How does the liquid get to the hose?
13) Give the maximum opening of strainers used in hand-operated hydraulic sprayers.
14) Why must sprayer hose be made of strong plastic or rubber material?
15) Why do cut-off valves, lances and nozzles have the same threads and sizes?
16) What are hydraulic energy nozzles?
17) Based on spray patterns, how do you classify various hydraulic energy nozzles?
18) Describe the relative usefulness of a fan nozzle and a cone nozzle.
19) Cite three characteristics that distinguish a compressed-air sprayer from a knapsack sprayer.
20) Why are knapsack sprayers particularly useful for boom spraying?

Suggested further readings

For specifications on sprayers:

World Health Organization. 1964. Equipment for vector control. World Health Organization: Geneva.

For components of sprayers:

Instruction or operating manuals of sprayers used.

3. OPERATING A KNAPSACK SPRAYER

Objectives: To be able to carry a knapsack sprayer, to apply pressure into it, to keep a constant walking speed and a constant distance between the nozzle and the top of the plant, and to spray successive swaths.

Materials: Each trainee will need:
1 knapsack sprayer
6 bamboo stakes, 1 x 2 x 100 cm
3 10-meter pieces of twine
Sufficient water to fill three fourths of a spray tank
1 stopwatch

Teaching aids: OHP transparencies showing a) the path to be travelled by sprayman in spraying successive swaths, and b) position of nozzle from tip of the plants.

INTRODUCTION

Emulsifiable concentrates of pesticides are cheaper than granules but quite often farmers do not obtain the best results from them. Many farmers complain that when they spray herbicides, even at the recommended rate, their plants are injured. It is possible that the spray solution was not prepared correctly, but most likely the trouble can be attributed to uneven spraying. To deposit the right amount of spray materials the operator should have special skills and practice. If a farmer can operate his sprayer correctly during spraying operations, he will not only do a good job of pest control but will also save considerable money in terms of expenses for pesticides and crop losses.

This lesson is designed to teach the necessary skills for operating a knapsack sprayer, the most widely used type of sprayer for rice pest control.

PRESENTATION

One or a combination of the following factors may cause uneven distribution of sprayed material on the crop: carrying of spray tank, pressure in the tank, speed of travel by sprayman, distance between nozzle and top of plant, and variations in spray swath.

A. *Carrying the knapsack sprayer*

All knapsack sprayers are provided with shoulder straps. Use the straps exactly as indicated in the operating manual. Be sure the sprayer is mounted on your back comfortably. If it is not well balanced on the back, operating it for an extended period becomes tiring because of the position in which it has to be pumped and the relative instability resulting from such off-balanced suspension on your back. The shoulder straps, when tied properly, prevent the sprayer from unduly moving or rocking from side to side while in operation.

B. *Applying pressure into the knapsack sprayer*

Steps	Key points
1 Connect all three assemblies of the sprayer	a) Mount the pump assembly on the spray tank. b) Attach components of the delivery assembly to the tank. Cut-off valve should be in shut-off position. c) Make sure all screws are tightened.
2 Fill the tank 3/4 full of water	a) Use clean water. b) Before pouring in water, make sure the strainer in the filler hole is in place.
3 Tighten filler cap	
4 Apply pressure into tank	a) Operate the hand-lever about 15 to 20 strokes, depending on instructions. b) Keep your face away from the point where the hose joins the tank because a break at this point can easily cause its contents to be discharged into your face. c) While pumping, check for leaks at removable parts.
5 Make a test spray	a) Hold nozzle about 1 meter above the ground pointing downward. b) Open the cut-off valve and see if the spray droplets are fine and uniform. If droplets are not fine (individual droplets can be distinguished with naked eyes) and spray projection is not straight, pump more pressure into tank. Note the additional number of strokes applied to the lever. If spray is not uniform, remove the nozzle and clean it properly.

Keep the pressure you have just developed constant throughout the spraying operation by operating the hand lever at a rate of about 15 strokes a minute, increasing this to 20 as the remaining spray material decreases.

C. *Speed of travel by sprayman*

Keeping your walking speed constant, particularly in the paddy soil, is another important factor in spraying. You should walk continuously at a constant rate while one hand is pumping and the other directing the nozzle. Don't stop unless necessary as stopping may disrupt the even pattern of spray.

D. *Distance between nozzle and top of plants*

Each nozzle has its characteristic spray angle (see lesson on "Sprayers"). As the distance between nozzle tip and the top of plants varies, the area covered by the spray material also varies. Therefore the distance should be kept uniform. In rice pest control, this distance is approximately 30 cm.

E. *Spray swaths*

A spray swath is the width covered by sprayed material in one pass during which the spray operator repeatedly swings the nozzle from left to right as he walks. Keep the width of this area within 1 and 1.5 meters. A wider swath may leave some portions of the area unsprayed as you walk forward.

APPLICATION

(Drill the trainees on the above five factors, preferably using the following procedure)

Carrying the knapsack sprayer

1) With an empty knapsack sprayer demonstrate how to use the shoulder straps correctly to carry the sprayer on the back.

2) Assign each trainee to do likewise. Ask him to pump five strokes on the hand lever. Check whether the sprayer is balanced on trainee's back and held in place tightly. Then proceed to next steps.

Applying pressure into the knapsack sprayer

Have the trainee:

1) Remove the sprayer from his back.

2) Fill the tank 3/4 full of clear water. The instructor should observe whether the strainer is left in the filler hole.

3) Tighten filler cap.

4) Without mounting the sprayer on the back, operate the lever about 15 strokes per minute. Check for any leakage.

5) Make a test spray. Observe key points as described in PRESENTATION above. Proceed to next steps.

Spraying successive swaths

Have the trainee:

1) Set up on a crop area the three 10-meter pieces of twine with the help of bamboo stakes to make three straight lines parallel to rows of plants. The lines shall be 1.5 meters apart.

2) Mount the sprayer on his back as described above.

3) Take position on the levee and in the middle of two established lines.

4) Hold the lance by the handle, straighten the arm so that the nozzle is about 30 cm from the tip of the plants.

5) Without turning on the cut-off valve, swing the arm from left to right at a rate of about one sweep per second. Make about 20 sweeps. NOZZLE MUST BE HELD CONSTANTLY ABOUT 30 CM ABOVE THE TIP OF PLANTS.

6) While continuously making sweeps from left to right, use the free hand to grasp the hand-lever of the sprayer pump and start pumping at a rate of about 15 strokes per minute. Rhythms of the two arms can easily be synchronized since there is one pumping stroke in every four sweeps of the nozzle. Count "one thousand one, one thousand two, one thousand three, one thousand four" repeatedly and continuously. At the end of each "one," "two," "three," and "four," the nozzle should be on the left or the right of established lines alternately. While at the end of "one thousand three" raise the hand lever and gradually lower it to its minimum position at the end of "one thousand four." He must do this until he gets used to the rhythm.

7) Drill his legs to synchronize with the rhythms of the arms by marking time while the two arms are operating rhythmically (moving the feet alternately without advancing). Do this until arms and legs are synchronized.

8) Open the cut-off valve and start walking to spray one swath along the two established lines. MAKE NORMAL AND CONSTANT STEPS ONLY. Try not to stop in the middle of the pass. When reaching the other side, stop and take position in between the two lines of the next swath.

9) Start spraying again. An overlap of about 10 cm on the previous pass may sometimes prove useful.

10) Repeat on the first pass if performance is not satisfactory.

EVALUATION

1) Although emulsifiable concentrates of pesticides are cheaper than their granular equivalents, why do some farmers hesitate to use them?
2) Cite two important benefits of proper operations of sprayers.
3) What may happen if the sprayer is not well balanced on your back?
4) In pouring liquid into the sprayer why is it necessary to keep the strainer in place on the filler hole always?
5) How do you judge whether pressure is sufficient in the tank?
6) Explain how constant speed of walking and distance between nozzle and plant tips affect the distribution of spray material.
7) What is a spray swath?

4. CALIBRATING SPRAYERS

Objectives: To be able to check the application rate of a sprayer, given a nozzle size and spraying pressure; to be able to determine the number of sprayer loads to treat a given area and amount of herbicide to mix in each load.

Materials: Each group of trainees will need:
1 steel tape measure or other measuring device
1 stop watch
1 graduated cylinder, capacity 1 liter
2 bamboo stakes, size 1 x 2 x 100 cm
Pencil and paper
1 knapsack sprayer, 15 1. capacity

Teaching aids : Slides or overhead projector transparencies showing a) spray from nozzle affected by different pressures, and b) spray swath affected by various distances between nozzle and ground

INTRODUCTION

Agricultural chemicals must be applied accurately. Too much spray material will injure the crop and is wasteful and costly. On the other hand, too little spray may not effect a good control. Calibration of the sprayer helps avoid most of these problems. It is a quick and accurate method of checking the application rate. Furthermore, every nozzle orifice wear out due to the fast moving spray material passing through it at high pressures. Calibration is, therefore, a frequent task in farm operations. This lesson is designed to demonstrate the step-by-step procedure in calibrating a sprayer.

PRESENTATION

You can obtain more accurate and reliable results if you use sprayers in good operating conditions. Follow procedures described in "Maintenance of sprayers."

Calibrate your sprayer periodically, preferably before each application of pesticides. The rate of application depends on:

1. *Pressure in the spray tank.*
Keep it as constant as possible. A pressure regulator or pressure gauge is usually provided in boom sprayers.

2. *Size of nozzle orifice.*
It regulates the amount of fluid passing through nozzles. Both nozzle orifice and pressure affect the volume of spray material delivered per unit time.

3. *Uniform spray swath.*
It is directly affected by the distance between nozzle tip and the top of the plant or ground level.

4. *Walking speed of sprayman.*
It affects the area to be covered per unit time.

These four factors should be considered when calibrating your sprayer.

The following procedure is designed for calibrating a knapsack sprayer with a single or a twin nozzle. With a modification on the measurement of the spray swath, the procedure may be used to calibrate a hand-operated boom sprayer equipped with several nozzles.

Steps	Key points
1 Prepare sprayer	a) Rinse and fill sprayer tank with clean water. b) Remove and clean the nozzle. c) Apply pressure and check for leaks. Then flush pump, hoses, and lance with clean water with nozzle and strainers removed. d) Replace nozzle and strainers. e) Refill the tank with clean water and apply pressure.
2 Determine walking speed of sprayman	a) Do this in an actual paddy field to be treated. b) Mark starting point with a stake. c) Carry sprayer on back and operate it as in actual spraying: one hand pumping, the other directing nozzle within a spray swath and walk at constant and normal speed. (See "Operating a knapsack sprayer.") d) Have a friend start stopwatch as you start walking. e) Stop walking exactly at the end of 1 minute. f) Mark the stop point with a second stake. g) Measure the distance between the two stakes. Record distance in meters; express the walking speed in meters per minute. h) Repeat at least three times to ensure an average walking speed.
3 Determine the width of spray or swath	a) Measure the width of spray or swath in meters. b) Maintain constant pressure in the tank and proper distance between nozzles and ground level.
4 Calculate area sprayed in 1 minute	If the spray swath is 1.5 meters and the walking speed was determined in Step 2: Area of spray per minute (m^2/min) = Spray swath (1.5 m x walking speed (m/min)
5 Determine nozzle discharge	a) Refill the sprayer with clean water and apply and keep pressure as in Step 1. b) With sprayer standing on the ground, dip spray nozzle into a graduated cylinder and open the cut-off valve to discharge water into the cylinder. Use another suitable measuring device if graduated cylinder is not available. c) Reset stop watch, and start it simultaneously as you turn on the cut-off valve. d) Shut off the valve exactly at the end of 1 minute. e) Note volume (liters) of water collected. This is the nozzle discharge expressed in liters per minute. f) Repeat at least three times to ensure an average nozzle discharge per minute.
6 Calculate application rate	Compute for the number of liters of spray material discharged in 1 hectare:

7 Calculate number of sprayer loads per hectare	$\text{No. of loads per hectare} = \frac{\text{Rate of application per hectare}}{\text{Tank capacity of sprayer (15 l)}}$
8 Calculate amount of liquid herbicide to mix in each load of sprayer	a) Compute amount of herbicide needed per hectare. (Refer to lesson 3B Chapter 6.) $\text{Amount of herbicide per load} = \frac{\text{Amount of herbicide per hectare (cc)}}{\text{Number of loads per hectare}}$

NOTE: This procedure is applicable when water is used as diluent in the pesticidal solution. If oil is the diluent, its viscosity will affect nozzle discharge. In this case calibrate the sprayer with oil instead of water.

APPLICATION

Have trainees perform Steps 1 through 8. Make sure that while operating the sprayer

(1) the trainees keep the nozzle 30 cm from the tips of the plant;

(2) the time is exactly 1 minute for each test.

Example 1. To walk in the paddy and to operate the sprayer with a spray swath of 1 meter, a trainee covered 20 meters per minute. Suppose the nozzle discharge was 0.4 liter/min., what is the application rate?

Calculations:

(a) Area covered by spray swath per minute: 1 m x 20 m/min = 20 m^2/min

(b) Application rate per hectare:

$$\frac{0{,}4 \text{ liter/min} \times 10{,}000 \text{ m}^2\text{/ha}}{20 \text{ m}^2\text{/min}} \quad 200 \text{ liters/ha}$$

Example 2. The formula in Step 6 may be used to calculate the volume of spray required for any area in the farmer's fields since the fields are usually divided into numerous small plots.

$$\text{Volume of spray per area (liters/area)} \quad \frac{\text{Nozzle discharge (liter/min)} \times \text{Area (m}^2\text{)}}{\text{Area sprayed in 1 min (m}^2\text{/min)}}$$

In example 1, if the area to be sprayed is 800 m^2, the volume of spray is:

$$\frac{0{,}4 \text{ liter/min} \times 800 \text{ m}^2}{20 \text{ m}^2\text{/min}} = 16 \text{ liters}$$

Example 3. When calibrating a boom sprayer, add volumes of spray water collected from each nozzle to determine total nozzle discharge. Spray swath depends on boom length, spray angle of nozzle, and distance from nozzles to tips of the plant. If a boom sprayer has six nozzles and each nozzle discharges 1.5 liter/minute, what is the application rate if spray swath is 2.4 meters and walking speed is 30 m/min?

Solutions:

Total nozzle discharge: 1.5 liter/min x 6 = 9 liter/min

Area covered by spray swath: 2.4 m x 30 m/min = 72 m^2/min

Application rate:

$$\frac{9 \text{ liter/min} \times 10{,}000 \text{ m}^2\text{/ha}}{72 \text{ m}^2\text{/min}} = 1250 \text{ liters/ha}$$

EVALUATION

1) Cite two important reasons for calibrating sprayers.
2) Cite four factors affecting the rate of application of a sprayer.
3) How do these four factors affect the rate of application?
4) In determining walking speed, what are the important points which you should observe?
5) How do you determine actual walking speed?
6) How do you determine area covered by spray swath in a minute?
7) How do you determine nozzle discharge?
8) Calibration 1: given a spray swath 1 m, nozzle discharge 1.25 liters/min, and walking speed 25 m/min, what is the volume of spray per hectare?
9) Calibration 2: if a spray swath is 1.5 m, nozzle discharge 2.55 liters/min, walking speed 25 m/min, what is the volume of spray per hectare?
10) Calibration 3: given a boom sprayer having 4 nozzles with a discharge of 0.60 liter per nozzle per minute a spray swath of 2.5 meters, and the sprayman's walking speed of 20 meters per minute, calculate the volume of spray per hectare. Calculate the number of loads of sprayer per hectare if tank capacity of sprayer is 15 liters. How much Hedonal 480 g/l will be mixed in each load of sprayer if the recommended rate of application is 0.8 kg a.i./ha?

Suggested further readings

Agricultural Extension Service. 1969. Calibrate your farm sprayer. Leaflet 317 (Rev.). U.S. Department of Agriculture and University of Arkansas, Arkansas.

Berge, I.O. 1967. Sprayer and granular applicator calibration. Circular 540. Cooperative Extension Programs. University Extension, The University of Wisconsin, Wisconsin.

University of the Philippines. 1970. Rice production manual. pp. 160-161. U.P. College of Agriculture, Laguna, Philippines.

5. ROUTINE MAINTENANCE OF SPRAYERS[1/]

Objectives: To be able to demonstrate the relationship of routine maintenance and proper care of sprayers to efficiency of job performance; to be able to clean and lubricate the moving parts of a knapsack sprayer.

Materials: Each group of trainees will need:
1 knapsack sprayer
1 piece clean wiping cloth
50 ml mixture of equal parts of kerosene and engine oil
Clean water

Teaching aids: Schematic drawings of a knapsack sprayer to be used in class and its operating manual

INTRODUCTION

A hand-operated hydraulic energy sprayer, such as the knapsack sprayer, is an essential piece of equipment for rice farmers. The sprayer may be costly but with proper care and maintenance it will give long years of service. Spraying of pesticides can be done at any time and with good results. Procedures for maintaining a sprayer are usually given in the operator's manual; understand and follow them. When purchasing a new sprayer obtain from the supplier all available information on its construction, maintenance, and operation.

This lesson is designed to supplement the manufacturer's information on the maintenance of sprayers.

PRESENTATION

The operator's manual for all sprayers should be kept in a binder, and in one place so that any time repairs or replacement parts are necessary, such important reference material can be found and referred to easily.

All sprayers that are often used should be cleaned regularly, at least once each week. Equipment not regularly used or used with various chemicals should be cleaned after using.
with a different chemical.

[1/] Reproduced from Scientific Guide To Pest Control Operations by permission of Purdue University, Lafayette, Indiana, U.S.A.

A. *Cleaning after each spraying operation*

When the spraying operation is finished, observe the following procedures:

Steps	Key points
1 Empty the spray tank of all remaining pesticide	a) Dispose *only* on waste land selected for this purpose (see lessons on "Handling of herbicides" and "handling of insecticides ").
	b) Do not contaminate irrigation canals, streams, and agricultural land.
2 Rinse the tank	a) Use clean water and detergent. Fill the tank one-third full and shake *vigorously*.
	b) In some models, rinsing the tank also cleans out the cylinder if the latter is located inside the tank.
3 Spray with the washings	This will wash dip tube, hose, lance, and nozzle. The nozzle may be removed after 2 minutes to speed up the washing process.
4 Repeat Steps 2 & 3	
5 Repeat Steps 2 & 3 without detergent	Use only clean water this time.
6 Drain the sprayer	Remove as much water from all parts as possible.
7 Protect external surface of the sprayer from corrosion	Rub the tank externally with a mixture of equal parts of kerosene and oil.
8 Prepare for storage	Return the sprayer to its original packing case.

B. *Routine maintenance procedures*

When any part of the sprayer does not function properly, correct the defect immediately. You can do the following things without the help of a repair man.

Strainers are located at different places on the discharge assembly. Refer to the operator's manual. Remove the strainers and back-flush with water in the reverse direction from the normal flow of sprayer material. When this does not remove all extraneous material on the screen, it may be necessary to soak the screen in a solvent (acetone, benzene, xylene, or kerosene) that will dissolve the pesticide that had been used. If the screen has been damaged or is impossible to clean thoroughly, replace it with a new one.

Cut-off valve should open easily and rapidly and should shut off quickly and tightly. Check the gaskets in the valve and replace the gaskets with new ones if spray leaks from the valve.

Hose should not have any break in the outer covering, particularly at points where the hose is fastened to any couplings. Replace the hose if any break is found. Never carry or store hose with sharp kinks in it, as this may cause breaks.

Nozzles require special care. Much of the effectiveness of any pesticide application depends on

the proper functioning of the nozzle. Nozzle tips are designed to give a specific pattern of spray with a specific kind of droplets, at a set pressure.

Clean nozzles with the following procedure (see fig. 3 of lesson on "Sprayers: parts and their functions").

Steps	Key points
1 Dismantle the nozzle	a) Unscrew the nozzle cap from the nozzle body. b) Remove nozzle tip and strainer.
2 Wash nozzle tip	a) Clean the hole in the nozzle tip by back-flushing with clean water. b) If the hole cannot be cleaned that way, use a bristle or copper wire that is softer than the material in the tip itself. The diameter of the wire should be smaller than the hole so that the tip is not damaged or enlarged while being cleaned. c) *Do not blow out the nozzle with your mouth.*
3 Clean strainer	See section B (above).
4 Assemble the nozzle	

Pump assembly. Lubricate plunger or piston leather cups in the cylinder frequently with animal or vegetable oil to soften it and to prevent loss of efficiency in pumping. Lubricate the piston rod also so that it moves freely and easily.

Replace leather cup if it becomes hard and worn-out.

APPLICATION

Assign one knapsack sprayer to each group of trainees. Drill them on routine maintenance procedures, as described in B.

EVALUATION

1) Explain why it is important that sprayers receive proper care and maintenance.
2) When buying a new sprayer, one should obtain from the supplier all available information on its construction, maintenance, and operation. How do you keep these documents?
3) How do you clean a sprayer after using it?
4) When cleaning strainers, should you flush water through them in the same direction of spray material? Why?
5) What is an important precaution in cleaning clogged nozzles?
6) How do you clean nozzles properly?
7) How do you store hoses?
8) How do you maintain maximum efficiency of the pump assembly?

6. WEED CONTROL

1. GENERAL CONSIDERATIONS IN CHEMICAL WEED CONTROL

Objectives: To be able to recognize the importance of time of application, determine proper dosage, and follow recommendations in applying herbicide; and to distinguish various formulations of herbicides.

Teaching aids: Samples of the following herbicides a) emulsifiable concentrates of 2,4-D, MCPA; b) wettable powder or water soluble powders of PCP WP 85 and Atrazine WP 50; and c) granules of Eptam-M, Hedonal, Treflan-R

Samples of three manufacturer's labels on herbicide containers

INTRODUCTION

Chemical methods of weed control offer the most practical, effective, and economical means of reducing crop losses and production costs due to weeds In the past, herbicides other than 2,4-D and MCPA have been regarded as too costly in many countries. This situation has been changed by the introduction of new herbicide formulations. Herbicides are presently available as in granular form ready for direct use, or as emulsifiable concentrates (EC), wettable powders (WP), and water soluble powder (WSP). However, to use these inexpensive chemicals to eliminate weeds in your ricefield effectively, you should understand the following three general precautions.

PRESENTATION

Apply herbicides at the right time

The performance and selectivity (control of weeds without injuring the crop) of most herbicides depend upon their application at the correct stage of growth of the weeds or the crop. Many herbicides are safe to apply to transplanted rice, but only a few will not kill direct seeded rice. Pre-emergence herbicides, such as 2,4-D and MCPA must be applied before germination of weed seeds because they are less effective after the weed seedlings have emerged from the soil. Post-emergence herbicides, such as Propanil, must be applied at later stages of weed growth because they may injure the rice if applied too early.

Apply herbicides at the right rates

Apply herbicides accurately because inadequate amounts give unsatisfactory weed control and excessive rates may injure the crop. Measure the exact amount of herbicide formulation and the area to be treated. Never rely on mere estimates. When spraying herbicides, calibrate properly. This takes a little effort and time, but it is worthwhile in terms of satisfactory results, economy, and safety.

Follow carefully manufacturer's instructions for each herbicide

Read the label on each herbicide container to find out the correct time and rate of application and other directions or precautions to be observed.

APPLICATION

1) Ask the trainee to make visual observation of the appearance (color, size, and shape of granules, or powder, apparent viscosity of the liquid) of various herbicide samples.

2) What is the difference between pre-emergence and post-emergence herbicides? Give an example of each.

3) What should be measured accurately when considering chemical weed control?

4) Show a manufacturer's label of a herbicide container and explain it. Ask the class to interpret other labels available.

EVALUATION

1) Cite three kinds of herbicides according to formulation.
2) What happens if herbicides are not applied at the right time?
3) Why should post-emergence herbicides not be applied before planting?
4) Why must herbicides he applied at the right dosage?
5) What should you look for on the label of an herbicide container?

2. WEED CONTROL BY HAND AND ROTARY WEEDER

Objective: To be able to eliminate weeds properly from a ricefield by hand weeding or with the rotary weeder.

Materials: 1 sickle for each trainee
1 rotary weeder for each group of trainees

Teaching aids: Slides showing a) ricefield with weeds at the two- to three-leaf stage, and b) steps involved in weeding by hand and with rotary weeder

INTRODUCTION

Weeds are the worst competitors of the rice plant. They compete not only for water and nutrients from the soil, but also for carbon dioxide and sunlight that help process or manufacture starch to fill the rice grains. Therefore, weeds should be eliminated. This is achieved by a combination of practices such as using pure rice seed, thoroughly preparing the land, keeping soil flooded, and planting in rows. This lesson is designed to teach you two methods of mechanical weeding: hand-weeding and weeding with the use of a rotary weeder.

PRESENTATION

Weeding by hand or with a rotary weeder is usually done 2 weeks after transplanting when the plants are well established in the soil and the weeds have two or three leaves.

A. *Hand weeding*

Steps	Key points
1 Uproot the weeds	a) It is difficult to grasp the weeds at the two- to three-leaf stage. Turn under the weeds by a combing and stirring action to the soil between the rice plants with fingers slightly apart. b) If weeds are 10 cm or more in height, uproot them by hand. c) Do not step on rice plants.
2 Push uprooted weeds into the mud	Do this after a handful of weeds has been collected.

It is generally necessary to weed again about 2 weeks after the first hand weeding.

B. *Weeding with a rotary weeder*

Steps	Key points
1 Reduce the water level	Do this only if water can be controlled and before applying any chemical in the field.
2 Push the rotary weeder forward between the rows	Complete weeding is accomplished by passing the weeder in two directions, first, lengthwise, then, crosswise. Push the weeder only between rows to avoid touching the rice plants and injuring the tillers.

Disadvantages of hand or mechanical weeding
a) Labor cost is high.
b) Rice roots are disturbed.
c) Some tillers may be damaged.
d) Operation is slow and laborious.

APPLICATION

Assign each trainee to a ricefield that has weeds at the two- to three-leaf stage, and perform:

a) Hand weeding

b) Weeding with rotary weeder

While the trainees are weeding, see to it that no damage is done to the rice plants either by their feet or hands. When using a rotary weeder they should avoid touching the rice plants.

EVALUATION

1) Why must weeds be eliminated from your rice-fields?

2) At what stage of growth of the weeds do you start hand weeding? Why?

3) Give one way of eliminating weeds from the field by hand.

4) How can you control weeds thoroughly with a rotary weeder?

5) Cite three disadvantages of weeding by hand and by the rotary weeder.

3. HERBICIDE CALCULATIONS

Objectives: To be able to define "active ingredient" or "acid equivalent," and to determine concentration of herbicides according to their formulations; to compute accurately for the required amount of commercial herbicide in wettable powder, water soluble powder, granular or emulsifiable concentrate forms needed to treat a given area at a given rate of active ingredient per unit area.

Materials: 1 pencil
2 sheets bond paper

Teaching aid: Conversion table from pound per US or imperial gallon to grams per liter

INTRODUCTION

Herbicide recommendation rates are often expressed as kilograms of active ingredient per hectare (kg a.i./ha). These rates have been carefully studied and tested to give maximum results. You must apply herbicide at the correct dosage. To achieve this, you need to calculate the exact amount of herbicide material to treat a given area.

PRESENTATION

The active ingredient (a.i.) of a herbicide is the principal chemical compound that acts on the weed. For herbicides that are salts of organic acids, their *acid equivalents* (a.e.) are considered. For example, if we have a sodium MCPA formulation containing 22.2 percent of sodium MCPA, this formulation would contain 20 percent weight/volume of acid equivalent.

In commercial solid formulations (WP, W.S.P., granules), the concentration is expressed as percentage of the weight of the a.i. by the weight of commercial solid herbicide (*weight/weight*). Example: Hedonal 3.2% granules contains 3.2 grams of isopropyl/ester of 2,4-Dichlorophenoxyacetic acid in every 100 grams of Hedonal.

In commercial liquid formulations (EC), the concentration is expressed as the weight of the a.i. by the volume of the commercial emulsifiable concentrate herbicide (*weight/volume*). Example: MCPA-sodium, emulsifiable concentrate 2 lbs a.i./gal contains 2 pounds of 2-methyl, 4-chlorophenoxy acetic acid in every gallon of the MCPA liquid herbicide (or 240 g/liter).

Herbicides in forms of emulsifiable concentrates, wettable powders, or water soluble powders must be diluted with water or other carriers such as oil. If proper dilution is not made, the effect of herbicide may be too weak or too strong; hence the herbicide may not control the weed effectively, or it may damage the crop. The amount of water for dilution, however, depends on the types of herbicide and the calibration of the sprayer (see Spraying Operation), but the amount of herbicide is fixed at a given herbicide rate and area to be treated.

When you have decided what herbicide is to be used in your field, the next task is to find out how much of that herbicide is required for the field. This amount will be affected by the recommended rate or dosage of active ingredient, the concentration of active ingredient in the herbicide, and the area to be treated. Your calculations on the other hand, may vary according to the forms of herbicide formulation (EC, WP, WSP, granules).

Conversion Table
Pounds per US or Imperial gallon to grams per liter and percent active ingredient

US			Imperial		
lb/US gal	g/liter	%	lb/Imp. gal	g/liter	%
1	120	12	1	100	10
2	240	24	2	200	20
3	360	36	3	300	30
4	480	48	4	400	40
5	600	60	5	500	50
6	720	72	6	600	60

A. Calculation for amount (in kg/l) of formulated product either in powder, liquid or granular form.

Steps	Key points
1 List all pertinent data	Write down a) *RR* for recommended rate of application in kilogram of active ingredient per hectare (kg a.i./ha). b) *A* for area to be treated in hectare (A (ha)). c) *C* for concentration of active ingredient in the herbicide formulation in percent (%).
2 Compute amount of herbicide per hectare	Formula $\frac{RR\ (kg\ a.i./ha) \times 100}{C}$
3 Compute amount of herbicide for a given area	Solid (WP, WSP, granules) Amount (kg) = $\frac{RR\ (kg\ a.i./ha) \times A\ (ha) \times 100}{C}$ Liquid (EC) Amount (liters) = $\frac{RR\ (kg\ a.i./ha) \times A\ (ha) \times 100}{C}$

APPLICATION

1) Use as an example the herbicide PCP-WP 85% and explain what it means. Ask the trainees to explain MCPA EC 2 and 4 lb/gal and 20% granule; Propanil EC 3 and 4 lb/gal; Eptam (EPTC) 5% and 10% granules and EC 6 lb/gal.

2) Sample calculation for wettable powder herbicide:
To apply 2 kg a.i./ha of PCP WP 85% to a 2,500 sq m field, how many kilograms of PCP WP 85% do you need?

RR = 2 kg a.i./ha
A = 2,500 sq m = 0.25 ha
c = 85%

$$\text{Required weight of PCP WP 85\%} = \frac{RR \times A \times 100}{c}$$

$$\frac{2 \times 0.25 \times 100}{85} = .588 \text{ kg}$$

3) Sample calculation for emulsifiable concentrate herbicide:
How many liters of MCPA EC 4 lb/Imp. gal. are required to spray a 500 sq m plot at the rate of 0.8 kg a.i./ha?

R = 0.8 kg a.i./ha
A = 500 sq m = 0.05 ha
c = 4 lb/Imp. gal. = 400 g/liter = 40%

$$\text{Required volume of MCPA} = \frac{RR \times A \times 100}{c}$$

$$= 0.8 \times 0.05 \times 000$$

$$= 0.10 \text{ liter}$$

$$\text{Required volume of MCPA} = \frac{RR \times A}{c}$$

$$= \frac{0.8 \times 0.05 \times 100}{40}$$

4) Sample calculation for granular herbicide:
How much Eptam-M (EPTC-MCPA) granule is needed for a field of 3.5 ha? Rate of application is 1.75 kg a.i./ha for Eptam, and Eptam-M contains 4.38% EPTC.

RR = 1.75 kg a.i./ha
(EPTC) 5% and 10% granules and EC 6 lb/gal.

RR = 1.75 kg a.i./ha
A = 3.5 ha
d = 4.38%

$$\text{Wt of Eptam-M required} = \frac{RR \times A \times 100}{c}$$

$$= \frac{1.75 \times 3.5 \times 100}{4.38}$$

$$= 139.84 \text{ kg}$$

5) From the example in No. 4, the trainees must recognize that granular formulation often contains more than one active ingredient. These are called combination herbicides made to eliminate all types of weeds in the ricefield. Examples: Trifluralin/2,4-D IPE or Treflan-R and EPTC-MCPA or Eptam-M.

EVALUATION

1) What is active ingredient?
2) What is acid equivalent?
3) When is concentration of an herbicide expressed in terms of weight by weight? And weight by volume?
4) Give one example each of a liquid herbicide, a wettable powder herbicide, and a granular herbicide.
5) What are the data needed in computing amount of herbicide to treat an area?
6) How many kilograms of Hedonal (2,4-D IPE) granules do you need to treat an area of 375 sq m at a rate of 0.8 kg a.i./ha? Hedonal contains 3.2% active ingredient.
7) With the same rate and same herbicide, compute the amount of Hedonal to treat:

   Plot A = 850 sq m
   Plot B = 900 sq m
   Plot C = 1,200 sq m
8) You plan to treat your soil intended for sorghum planting with Atrazine 50 WP. How many grams of this herbicide are needed to treat a 1,000 sq m area?
9) How many kilograms of Nitram 75% WP do you need to treat an area of 2,500 sq m at the rate of 2 kg a.i./ha?
10) MCPA emulsifiable concentrate containing 4 lb/US gal is used to spray a field of 1.5 ha at a rate of 0.8 kg a.i./ha. How many tablespoons of MCPA liquid would be needed? (Assuming that 1 tablespoon = 10cc).

4. APPLYING GRANULAR HERBICIDES

Objective: To be able to broadcast uniformly a required amount of granular herbicide over a given area.

Materials: Each group of trainees will need:
1 kg Hedonal
1 plastic bag or any suitable container

Teaching aids: Slides showing a) steps involved in broadcasting granular herbicides, and b) leaf damage due to broadcasting granular herbicide when plant leaves are wet

INTRODUCTION

Granular herbicides are easier to apply than other formulations of herbicides. They can be spread by mechanical spreaders, but for small farms spreading by hand is more economical. Herbicides, however, if not applied correctly, can easily injure your crop or fail to control weeds in your field.

PRESENTATION

Manufacturers of various granular herbicides specify the time of application of their products. However most granular herbicides may be applied 4 days after transplanting. If applied much later than this, their effectiveness will be reduced because by then weed seeds shall have reached an advanced stage of germination. The procedure is as follows:

Steps	Key points
1 Compute the exact amount of herbicide to be applied	See "Herbicide calculations - granular herbicides."
2 Weigh the herbicide	Place the granules in a plastic bag or suitable container.
3 Check the area to be controlled	a) Water level in the paddy must be at least 2 to 3 cm deep. b) All levees must be closed. Check for seepage.
4 Broadcast the herbicide	See "Broadcasting granular materials" and observe the following: a) Your hands must be dry. b) Plant leaves must not be wet. c) Avoid broadcasting in strong winds. d) Wash hands thoroughly with soap and water after handling herbicides.
5 Keep the levees closed at least 5 days after application	

APPLICATION

Assign a paddy to each trainee group and have trainees perform Step 1 through Step 4 using Hedonal granules.

EVALUATION

1) Why do you keep all levees closed and have at least 2 cm of water before applying granular herbicides to the paddy?
2) What is the purpose of drying your hands before broadcasting granular herbicide?
3) What may happen if granular herbicides are applied when plant leaves are wet?
4) Why is it essential to apply granular herbicide at 4 days after transplanting, but not at and not later?

5. PREPARING HERBICIDE SPRAYS

Objectives: To be able to mix herbicides of wettable powder and emulsifiable concentrate forms with a predetermined amount of water.

Materials: Each group of trainees will need:

30 g Nitralin 75% WP	1 bamboo stirrer
20 ml MCPA, EC 480 g/liter	1 scale
1 container, capacity 15 liters minimum	1 graduate cylinder

(Note: If graduated cylinder and scale are not available, use a milk can tablespoon, teaspoon, or any other common container. These containers must be previously calibrated by the instructor.)

Teaching aids: Slides showing wettable powder, herbicide floating on surface of water

INTRODUCTION

All granular herbicides can be used directly. But herbicide in the form of wettable powder, as well as emulsifiable concentrates, should be mixed with water or other diluting liquid such as oil before use. If you mixed it properly, your herbicide should work effectively. This lesson shows how herbicide sprays should be prepared.

If any common container is used, label it properly and keep it away from children.

PRESENTATION

Steps	Key points
1 Assemble pertinent data	a) Weight of WP (wettable powder) or volume of EC (emulsifiable concentrate) as computed from herbicide calculations. b) Volume of water as computed from "Sprayer calibration."
2 Compute the number of sprayer loads	
3 Compute the amount of herbicide	
4 Measure the computed weight or volume of herbicide	a) Measure correctly the required amount of herbicide. b) Remember too much herbicide may injure the crop and too little herbicide may not control weeds effectively.
5 Pour 1/4 of the required water into the container	a) Use clean water. b) The container should contain more than the sprayer tank. c) Never place herbicide ahead of the water because the wettable powder tends to float and many emulsifiable concentrates are acidic.

6 Add the herbicide to the water container	If using wettable powder, thoroughly mix it with a small amount of water before pouring it into the water container. This makes dispersion of the powder in a larger amount of water easier.
7 Mix the herbicide	Use a stick, not your hand.
8 Add remaining water to complete dilution	

APPLICATION

A. Have each group of trainees mix Nitralin 75% WP in enough water to fill a 14-liter knapsack sprayer. The sprayer had been calibrated and you found that 1,260 liters of herbicide spray is needed to cover each hectare. The rate of application is 2 kg/ha a.i.

1) First calculate the number of knapsack sprayer loads to spray 1 hectare:

$$\frac{1260 \text{ liters}}{14 \text{ liters/load}} = 90 \text{ loads}$$

2) Total amount of Nitralin 75% WP needed:

$$\frac{100 \text{ RRA}}{c} = \frac{100\ (2)\ (1)}{75} = 2.7 \text{ kg}$$

This is for the whole hectare, or 90 knapsack-sprayer loads.

3) For each load, the amount of Nitralin 75% WP to be mixed is:

$$\frac{2.7}{90} = 0.03 \text{ kg or } 30 \text{ g}$$

4) Ask the trainees to mix 30 g of Nitralin 75% WP in 14 liters of water in a container, but *not* in the sprayer.

B. Do the same exercise but with MCPA 480 g/l emulsifiable concentrate with a recommended rate of 0.8 kg a.i./ha.

EVALUATION

1) Before mixing the herbicide with water, why do you measure the required amount of herbicide with great care?
2) Why do you not place herbicide in the container before pouring water?
3) Why do you pour only part of the total amount of water before adding herbicide?
4) How do you facilitate the dispersion of wettable powder in water?

6. SPRAYING HERBICIDES

Objectives: To be able to apply liquid herbicides correctly and to be able to minimize hazards from spraying herbicides.

Materials: Each group of trainees will need a knapsack sprayer which has been calibrated previously and is filled with water.

Teaching aids: Overhead projector transparencies showing wind directions and corresponding spraying methods. Slides showing sprayman spraying a ricefield (focus on distance between nozzle and ground level).

INTRODUCTION

Spraying herbicides is one of the most difficult jobs in the farm. Your crop or neighboring crops can easily be damaged if care is not exercised. There are a number of precautions which should be observed when spraying herbicides. This lesson is designed to help the trainees identify the problems in spraying herbicides and to minimize the chances of damage due to mishandling.

PRESENTATION

After identifying the weeds and determining what herbicide to use, you will need to calculate the amount of herbicide needed and to calibrate your sprayer. You will then be ready to carry out the the spraying operation.

Steps	Key points
1 Check the weather condition	a) Spray during a sunny day. b) Check wind direction to prevent injury to other crops due to drift.
2 Survey the area	Make sure that the material being applied will not affect neighboring crops.
3 Check pressure in spray tank and other parts	See instructions for sprayer.
4 Start spraying	a) Avoid spray drift. Spray only when there is no wind movement toward a susceptible crop. b) When spraying in windy weather, spray downward as this causes slightly less drift than spraying upwind or crosswind. c) Always keep the distance between the nozzle and ground level constant. d) Keep your walking speed constant. e) Shake the spray can frequently to keep wettable powder or emulsifiable concentrate in suspension if a sprayer is not provided with agitators. f) Keep the tank pressure constant. g) Do not smoke.
5 Wash the spray tank	Properly dispose of excess chemical (see "Handling herbicides") See discussion "Preparing the sprayer for storage."
6 Wash your hands	

APPLICATION

1) Assign trainees a crop area having sufficient weeds.
2) Assist the trainees in selecting the appropriate herbicide to be used (based on lectures on herbicides).
3) Have trainees perform all necessary operations for spraying.

EVALUATION

1) Why is spraying herbicides one of the most difficult jobs among farm operations?
2) What information do you need before you consider spraying?
3) Why is a sunny day appropriate to spray liquid herbicides?
4) Why do you need to know the kind of crops being grown in the surrounding areas before spraying?
5) Explain how you can avoid spray drift.
6) It is not advisable to spray when weather is windy. But in case the spraying must be done at that time, how will you spray?
7) If wettable powder or emulsifiable concentrates are used, why do you need to shake the spray can frequently?
8) What is the importance of keeping constant the distance between the nozzle and the ground level, and your walking speed?

7. HANDLING HERBICIDES

Objectives: To be able to dispose of diluted herbicidal solutions and empty herbicide containers; to store herbicides; and to list the safety code for handling agricultural chemicals.

Teaching Aids: An empty herbicide bottle and an empty herbicide box
Slides showing effect of EPTAM on stored seed

INTRODUCTION

Herbicides are poisonous chemicals. They are made to kill undesirable plants. If misused, they may also destroy the crop to which they are being applied. There are several ways in which you can mishandle herbicides without knowing it. Therefore you need to be aware of the precautions essential in handling them.

PRESENTATION

A. *Disposal of diluted herbicidal solutions*

You should be able to use all the herbicide mixture to treat the selected area if you have calibrated your sprayer carefully and performed the spraying operation in conditions similar to those of the calibration. But some material may remain in the tank after the job has been completed. This material should be sprayed on waste land where it will not be harmful. You may want to select an area for this purpose. Never pour herbicide spray tank washings in the main drainage system, ponds, septic tanks, or on agricultural land.

B. *Disposal of herbicide containers*

Herbicides are marketed in a variety of containers. All empty containers must be cleaned and disposed safely as follows:

a) Containers for liquid herbicides: Wash out the liquid herbicide thoroughly and add the washings to the spray tank before completely filling with water. Store the washed container in a safe place. Dispose of metal containers to a metal merchant after you have punched holes into them to prevent re-use.

b) Cardboard boxes, paper sacks, and similar packs: Bury the containers in a disposal pit. No containers should be burned as some herbicides, when burned emit vapors which may cause damage to nearby crops.

C. *Storing herbicides*[1/]

a) Store herbicides in a well ventilated place that can be locked. Vaporization of herbicides can damage sensitive plants and seeds.

b) Store herbicides separately from fertilizers, insecticides, seeds, and planting materials. They should be clearly labelled.

c) Avoid exposing herbicides to extremes of temperature and to high humidity. Temperature affects herbicide formulations, particularly the wettable powders and granules, thus resulting in decomposition and chemical breakdown. High humidity may cause caking of solid products like wettable powders, dust, and granules.

d) If a container is opened, protect the remainder from exposure to the atmosphere.

e) If spraying is to be stopped because of a change in the weather, any unused diluted material should be removed from the sprayer and stored temporarily in a suitable noncorrosive container, clearly labelled with the name of the chemical, the extent to which it has been diluted, and the date of preparation.

D. *Safety code for handling agricultural chemicals*[2/]

a) Always read the label on chemicals before using sprays or dust. Note warning and cautions each time before opening the container.

b) Keep sprays and dusts out of the reach of children, pets, and irresponsible people. They should be stored outside of the home, away from food and feed. (Herbicides should not be stored near seeds.)

c) Always store sprays and dusts in original containers and keep them tightly closed. Never keep them in anything but the original container.

d) Never smoke while spraying or dusting.

e) Avoid inhaling sprays or dusts. Wear protective clothing or masks if required by instructions.

f) Do not spill sprays or dusts on the skin or clothing. If this happens remove contaminated

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1/ Reproduced from Weed Control Handbook by permission of Blackwell Scientific Publications Ltd., Oxford, England.

2/ Reproduced from Chemical Weed Control Handbook by permission of National Agricultural Chemicals Association, Washington, D.C.

clothing immediately and wash thoroughly.

g) Wash hands and face and change to clean clothing after spraying or dusting. Also wash clothing each day before re-use.

h) Cover food and water containers when treating livestock or pet areas. Do not contaminate fishponds.

i) Use separate equipment for applying hormone-type herbicides in order to avoid accidental injury to susceptible plants.

j) Always dispose of empty containers so they cannot harm humans, animals, or valuable plants.

k) Observe label directions and cautions to keep residues on edible portions of plants within the limit permitted by law.

l) If symptoms of illness occur during or shortly after spraying or dusting, call a physician or get the patient to a hospital immediately.

APPLICATION

Have trainees apply the information on handling herbicides when they actually prepare spray solution and after they have completed a spraying operation.

EVALUATION

1) Why can you pour diluted herbicidal solution on waste land but not on agricultural land?
2) What are the safest ways of disposing of herbicide containers?
3) Why is it necessary to store herbicides away from seeds and other planting materials?
4) In what ways do high humidity and temperature affect stored herbicides?
5) Should unused diluted herbicidal solution be sotred in spray tanks? Why?
6) It is always necessary that you read the label before using herbicides. What information do you need?
7) What are the safety measures to guard children, pets, domestic animals, and fish against contamination by herbicides?
8) Describe how you should dispose of diluted herbicidal solutions.
9) Describe the steps involved in disposing of liquid herbicide containers.
10) How do you safely destroy herbicide containers such as cardboard boxes, paper sacks, etc?
11) Cite five precautions in the storage of herbicides.
12) Cite at least six items in the Safety Code for Handling Agricultural Chemicals.

7. INSECT CONTROL

1. DEFINITIONS AND CLASSIFICATION OF INSECTICIDES

Objectives: To be able to define pesticides and insecticides and to classify insecticides according to their physical state and their mode of killing the insect pest.

Materials: Samples of insecticides locally available as dust, wettable powder, granules, and emulsifiable concentrate forms

Teaching aid: List of insecticides most commonly used in rice production

INTRODUCTION

From the sowing of seed to the sale of harvested rice you must adequately protect your crop against insect pests. You may control insect pests through:

1) Cultural control: by modifying a system of culture by crop rotation and by farm sanitation practices;

2) Biological control: by promoting the existence of natural parasites of insect pests or by introducing new species of parasite from another country. Example: the fly, *Sturmiopsis inferens*, a parasite of rice stem borer imported from India into the Philippines;

3) Breeding of resistant varieties by incorporating insect-resistant genes in the high-yielding varieties. Examples: rice variety Mudgo from India is resistant to biotype 1 of the brown planthopper, Pankhari 203 to the green leafhopper, and TKM-6 to stem borers;

4) Chemical control: by destroying insect pest by use of insecticides.

In controlling pests you deliberately initiate, maintain, or intensify an action to prevent, reduce, or eliminate the damage they cause. The first three methods of control listed above require time to become effective while immediate results can be achieved with the fourth method. Today most successful farmers obtain high yields because they practice good crop protection, chiefly through the use of pest-killing chemicals. To use insecticides intelligently and effectively, one should be able to identify the various forms of insecticides and to understand their effectiveness and mode of killing the insect.

PRESENTATION

"Pesticides" is a collective term covering all materials used to control, destroy or mitigate pests. The word "pest" covers all harmful insects, nematodes harmful to plants, microorganisms causing diseases in plants, rodents, and noxious weeds. Thus the term "pesticides" includes insecticides, herbicides, fungicides, rodenticides, nematocides, acaricides, algaecides, repellents, etc.

"Insecticides" are chemical compounds used to kill insects. They may include acaricides, nematocides, repellents, etc.

Classification of insecticides

Insecticides may be classified according to their mode of action on the insect or according to their physical states or formulations.

1. Classification according to formulations

a) *Dusts* — dry powder insecticides; available as pure insecticides, or as mixtures of insecticides with inert powders. They are effective as long as they remain dry; when moistened they may cake and become ineffective.

b) *Wettable powders (WP)* — made by impregnating an inert powder with an insecticide and then adding a wetting agent so that the powder particles can be suspended in water upon dilution. They leave the greatest possible residue than any toxicant on the sprayed surface.

c) *Granules* — Free-flowing grains or inert materials either mixed or impregnated with an insecticide. They do not need any further dilution or mixing, present no drift problem during application, and can be broadcast by hand.

d) *Emulsifiable concentrate (EC)* — liquid mixture of toxicant (insecticide) in its solvent (usually an aromatic oil) with an emulsifying agent which makes it possible for small droplets of the solvent carrying the toxicant to remain dispersed through the water when diluted. Emulsions penetrate porous materials, leaving the toxicant on the sprayed surface.

LIST OF INSECTICIDES MOST COMMONLY USED IN RICE PRODUCTION

Common Name	Trade Name & Formulation 1/	Chemical Group	Physiological Activity	Toxicity: Mammal 2/ LD50, mg/kg	Toxicity: Other animals	Phytotoxicity	Persistence	Non-compatibility	Remarks
Monocrotophos	Azodrin (EC) Nuvacron (EC)	Organophosphate	systemic and contact	21	highly toxic to ducks and geese	none 3/	non-persistent	alkaline pesticides	
Carbaryl	Sevin (WP)	Carbamate	contact and stomach	850	toxic to fish	may damage tender foliage	moderately persistent	lime, lime sulfur, bordeaux, or other alkaline pesticides	Residual action lasts to 35 days depending on growing conditions. Wait 7 days before eating treated crop.
Diazinon	Basudin (G)	Organophosphate	contact and stomach; can act systemically	108	highly toxic to ducks and geese, fish	none	non-persistent	copper compounds	Residual action lasts 7 to 10 days. No off-flavor effect on crops.
		Chlorinated hydrocarbon	contact and stomach	113	highly toxic to fish	none	very persistent	alkaline pesticides	Use with caution. Build up of concentration in fish has been reported.
Endosultan	Thiodan (EC, WP, G)	Organophosphate	contact and stomach	43	highly toxic to fish	may damage some legumes and fruit trees	non-persistent	alkaline and acid pesticides	
Fenitrothion	Folithion (EC) Sumithion (EC) Accothion (EC, WP)	Organophosphate	contact and stomach	250	toxic to fish	toxic to cotton	moderately persistent		Long residual effect.
Gamma-BHC (Lindane)	Dol granule (G) Gammexan (G, EC) Agrocide (G, EC) etc	Chlorinated hydrocarbon	contact and stomach; fumigant; can act systemically	125	toxic to fish	non-phytotoxic but causing off-flavor in crops	persistent (1 year or more)	lime, lime sulfur, and calcium arsenate	Long residual effect.
Malathion	Malathion (EC)	Organophosphate	non-systemic contact and stomach	1000		non-phytotoxic, but may damage cucumber, squash, stringbeans	slightly persistent	alkaline pesticides	Short residual effect.
Methyl parathion	Folidol M (EC)	Organophosphate	non-systemic contact and stomach; fumigant	9	toxic to fish	none	non-persistent	alkaline pesticides	Short residual effect. (5 days)
Phosphamidon	Dimecron (EC, WP)	Organophosphate	systemic; contact	23.8	harmless to fish	none	non-persistent	alkaline pesticides, copper oxichloride	Short residual effect. (5 days residue in most crop is 0.1 ppm)
Phorate	Thimet (EC, G)	Organophosphate	systemic; contact and fumigant	1.1		slight chlorosis has been reported (on seedlings)	slightly persistent	alkaline pesticides	Long residual effect (4-12 weeks).

1/ Formulation: EC - emulsifiable concentrate
WP - wettable powder
G - granule

2/ Acute oral LD_{50} for rats.

3/ Non-phytotoxic at recommended rate.

References: Reproduced from Agricultural Chemicals, Book I, Insecticides, by permission of Thomson Publications, Indianapolis, Indiana, U.S.A. and from Pesticide Manual by permission of British Crop Protection Council, London.

2. Classification according to mode of physiological action

a) *Stomach poisons* must enter through the alimentary tract to kill the insect.

b) *Contact poisons* penetrate or damage the body wall to be effective.

c) *Fumigants* enter the body through the respiratory system causing death. They are gas-producing substances that are applied in any form that volatilizes. Examples: soil fumigant, parathion, paradichlorobenzene.

d) *Systemic poisons* are mainly stomach poisons taken up and translocated by the plant either from applications to the soil, paddy water, or plant surface. Examples: diazinon, azodrin.

3. Classification according to methods of application

a) *Foliar insecticides* — applied by spraying over the surface of the plant or, as in the case of brown planthoppers toward the base of the plant.

b) *Systemic insecticides* — applied by broadcasting on or incorporating into the soil where they are absorbed by plant roots and translocated to other parts of the plant.

4. Classification according to chemical groups[1/]

Of all insecticides, those commonly used in the control of insect pests of rice may be grouped into:

a) Chlorinated hydrocarbon insecticides (aldrin, BHC, DDT, chlordane, dieldrin, endrin, heptachlor, thiodan, etc.). Generally these compounds produce a neuroactive principle in the blood that could cause death.

b) Organophosphorus insecticides (diazinon, guthion, malathion, methyl parathion, parathion, phosphamidon, etc.) These compounds act to inhibit cholinesterase, a vital enzyme which controls the activities of the central nervous system.

c) Carbamate insecticides (carbaryl). Mode of action is similar to that of chlorinated hydrocarbon insecticides.

APPLICATION

Distribute a list of the most commonly used insecticides, and discuss their classification according to formulation, mode of physiological action, and concentration.

EVALUATION

1) How does an "insecticide" differ from a "pesticide?"
2) Cite four ways in which you can classify an insecticide. Give one example for each.
3) Define and give an example of each of the following: wettable powder, dust, and emulsifiable concentrate insecticides.
4) From the list of insecticides, gamma-BHC is not a systemic poison. How does gamma-BHC granules work when applied in paddy water?

1/ For detailed discussion on the mode of action of various insecticidal compounds, see R.D. O'Brien, "Insecticides — action and metabolism" (New York: Academic Press, 1967).

2. SELECTING AN INSECTICIDE

Objective: To be able to identify and use the criteria for selecting an appropriate insecticide material to prevent an occurrence, or to reduce or eradicate a population of harmful insects.

Materials: A control guide for destructive rice insects (*1976—1977 Interagency Insect Control Guide for Lowland Transplanted Rice in the Philippines).*

Teaching aids: Slides showing hopper burn in diazinon-treated plot against healthier control plot
Slides to illustrate various local insect infestation in rice, showing insects at different stages of development

INTRODUCTION

Insect damage may occur at any time during the production of a crop of rice. A wise farmer will take action to prevent an insect attack as soon as he discovers the pest on his crop. He can achieve this by practicing control measures called *preventive control*, such as the following:

1) Plant insect-resistant, high yielding varieties.
2) Keep fields clean by destroying the breeding places for insects, e.g. weeds along dikes.
3) Apply insecticide at regular intervals (see "Applying granular insecticides" and "Spraying insecticides").

If an outbreak of a certain insect infestation occurs (e.g. large population of brown planthoppers at flowering stage), immediately take measures to reduce or eradicate the insect population. This is called *curative control* and requires the selection of an insecticide.

When more than one insecticide is available, the farmer must be able to choose the insecticide best suited for the particular pest. Besides the relative cost of the insecticides and their effectiveness, the farmer must consider other equally important criteria to provide his crop with sufficient protection.

This lesson describes these criteria for selecting an insecticide.

PRESENTATION

A. *Terms frequently used in selecting insecticides*

Acute oral LD_{50} — dosage required to kill 50% of the test animals (usually rats) when given a single dosage by mouth. It is expressed in milligrams of toxicant per kilogram of body weight of the test animal (mg/kg).

Phytotoxicity — characteristic of a compound that kills or injures plants.

Residual effect — the persistence of the insecticide or its derivatives on or in the plant, and in the water supply and soil. Some insecticides, like diazinon for instance, are broken down in a few days by soil micro-organisms (biodegradation), while chlorinated hydrocarbons, e.g. DDT, endrin, are persistent insecticides, that is, they remain effective for a much longer period.

Resistance of insects to insecticides — this does not mean that insects develop substances within their bodies which cause them to become immune to a certain insecticide. Resistance is due to selection within a population of the insect; the insecticide is the selecting agent. Those insects susceptible to the chemical are killed leaving those which are resistant to breed and produce subsequent resistant generations.

EXAMPLE

CONTROL GUIDE FOR DESTRUCTIVE RICE INSECTS IN THE PHILIPPINES

U.P. College of Agriculture, The International Rice Research Institute and the Bureau of Plant Industry

Insect	Insecticides: Common Name	Insecticides: Typical Brand Names	Formulation***	Rate (Kg a.i/ha) per application	Remarks
Stemborers (Yellow, striped, white and pink*)	Diazinon	Bazudin	G. or EC	2	Well timed insecticide (diazinon, etc.) treatments to control stemborers and leafhoppers may also effectively control many other insects; such as rice maggots, whorl maggots, rice thrips, leaf folders, armyworms, cutworms, etc.
	Fenitrothion	Accothion Folithion Sumithion, etc.	EC	1	
	Gamma-BHC (Lindane)	Dol granule	G or EC	2	
		Gammexane	G or EC		
		Agrocide	G or EC		
		San gamma, etc.	G or EC		
	Gamma-BHC + Carbaryl	Sevidol	G	2	Spray or broadcast with granules two to three times during the season. In areas where early infestation of borers occurs treatments are made at about 10, 40, and 70 days after transplanting. Inspect plants at least weekly for presence of young larvae. In areas where infestation is relatively late, treatment may be done 30-40 days after transplanting and second treatment at about 60-70 days after transplanting.
	Malathion + Fenitrothion	Ambithion	EC	1.5	
	Methyl Parathion**	Folidol Mepaton Meptox, etc.	EC		
	Endosulfan	Thiodan	EC	2	
	Phosphamidon**	Dimecron	EC		
	Carbofuran	Furadan	G	1-2	
Leafhoppers and planthoppers	Carbaryl	Sevin	WP	2	Hopper population builds up very rapidly especially in areas of intensive rice production. Inspect plants at least weekly; early in the morning, and examine area near base of inner tillers.
	Diazinon	Basudin	G or EC	1-2	
	Methyl parathion**	Folidol	EC	1	
		Meptox	EC		Spray the plants thoroughly every 10 to 14 days during dry season. (Planthoppers feed along base of inner tillers so coverage must be thorough). Spray very early in the morning when hoppers are active. Frequent rains during the wet season reduce effectiveness of foliar sprays. May need to treat weekly during wet season until control is obtained.
		Mepaton, etc.	EC		
	Phorate**	Thimet	G	1-2	
	Carbofuran	Furadan		1-2	
	MIPC	MIPCIN	WP	0.75	
	BPMC	Baycarb	EC	0.75	
	MTMC	HOPCIN	WP	0.75	
Rice whorl maggots, rice thrips, leaf folders					Insecticides such as gamma BHC, methyl parathion, diazinon, carbaryl, etc., applied early for control of stemborers and hoppers also will effectively control this group of insects.
Rice bug	Carbaryl	Sevin	WP	2	Must be controlled with contact foliar spray insecticides. Start treatment when feeding becomes noticeable or when one can catch two bugs per sweep of insect net. Two or three treatments may be necessary.
	Endosulfan	Thiodan	EC	2	
	Malathion	Malathion	EC	1	
	Methyl parathion**	Folidol Meptox Mepaton, etc.	EC	1	
Armyworms and cutworms	Carbaryl	Sevin	WP	2	Start treatment as soon as young larvae appear. Early treatment is essential for effective control.
	Diazinon	Basudin	EC	1	
	Malathion		EC	1-2	
	Methyl parathion**	Folidol, etc.	EC	1	
Seedbed insects	Carbaryl	Sevin Vetox	WP	1 g/10 sq m	Effective control of leafhopper-planthoppers is obtained by using carbaryl, diazinon. Leaf feeders such as armyworms and cutworms are more effectively controlled by applying the other insecticides as sprays. Start the treatment 5 days after seedling emergence or in the case of leaf feeders, when feeding marks on the leaves are noticed. Spray the seedlings to the point of run-off. With the granulars, apply the insecticide by broadcasting into the seedbed. If it is a dapog type, the granules can be broadcast on the germinating seedlings.
	Diazinon	Basudin	EC G	3 g/10 sq m	
	Methyl parathion	Folidol	EC	1 g/10 sq m	
		Meptox	EC		
		Mepaton	EC		
	Malathion	Malathion	EC	1 g/10 sq m	

* Gamma BHC *cannot satisfactorily control pink stemborers*

** Highly toxic to humans and animals. Should be applied only by trained personnel.

*** *G = granules, EC = emulsifiable concentrate, WP = wettable powder,*

**** *To compute for amount of commercial materials required on a hectare basis, use the formula:*

(a) Kilograms of Commercial materials (for granules and wettable powder) $= \frac{\text{Recommended rate (kg/ha.)}}{\text{o/o toxicant in granular or wettable powder commercial formulations}} \times 100$

(b) Gallons of commercial materials (for emulsifiable concentrate) $= \frac{\text{Recommended rate (kg/ha.)} \times 26.40}{\text{o/o toxicant in E.C. commercial formulations}}$

B. *Suggestions for selecting an insecticide*

Steps	Key points
1 Identify the insect causing the problem in your crop	a) Note the appearance of or symptoms caused by common insect pests of the crop in the area. b) Note the stage of development of the insects (eggs, larvae, nymphs, adults). — Foliar spray of a contact or stomach poison would work well on nymphs, and adults, as well as eggs. — For larvae of stem borer, a systemic insecticide or one which acts as a systemic insecticide (e.g. lindane), would be more effective.
2 Decide what insecticide to use	a) Select from the list of insecticides available in your community. b) The insecticide must kill the insect identified. Base your judgment on results of experiments on insect control. c) It should have a negligible residue problem. Persistent insecticides may generate undesirable effects. d) Its toxicity to mammals must be as low as possible, i.e. its acute oral LD_{50} value should be as large as possible. This is important especially for farmers who raise fish, ducks, etc. in their ricefields. e) If known, its phytotoxicity should be low. f) Consider the resistance of insects to the selected insecticide. An insecticide may lose its effectiveness to the same insect population after being used crop after crop. If you decide to apply the same insecticide you used in the last few crops, note whether its effectiveness is declining. If it is, select another insecticide. g) Assess the economic benefits that may be expected from using the insecticide. Consider the cost involved and the extent of the damage caused by the insects: application of an insecticide to control a severe late stem borer attack near harvesting time may not be worth the expense. Use the insecticide only when the value of the extra crop expected as a result of insect control is greater than the cost of chemicals and cost of application. h) Finally consider your ability to apply the insecticide. Granular insecticides used in a small-sized rice farm do not require expensive equipment for application. Liquid formulations require spraying equipment and more time to apply.

APPLICATION

Give examples of acute oral LD_{50}, and ask the trainees to select the least toxic one. Do likewise for phytotoxicity and residual effect.

Distribute the "Control guide for destructive insects" and discuss it. Under each insect heading, ask the trainees which insecticide he would select (give the prices of the insecticides and their availability). Refer to list of insecticides for information on toxicity.

EVALUATION

1) What is preventive control? curative control?
2) Cite and explain three terms frequently considered when selecting an insecticide.
3) Between insecticide A, with an acute oral LD_{50} of 88 mg/kg, and insecticide B with an acute oral LD_{50} of 6.5 mg/kg, which is the less toxic?
4) Give an example of a persistent insecticide.
5) Given the following ricefield situation:

   Variety — IR20

   Growth stage — 6 days after panicle initiation

   Insect situation — infestation of rice bugs and leaf folders

   Question: What insecticide should you select to control the insects? Explain your reason.
6) Experiments have shown that a 5% incidence of deadheart does not significantly affect final yield, and that an incidence of 10% or more decreases yield significantly. What and how many insecticides would you choose to control each situation? Explain.

3. INSECTICIDE CALCULATIONS

Objectives: To know the meaning of terms commonly used in insecticide calculations; to be able to compute accurately the amount of insecticide in wettable powder, granular and emulsifiable concentrate forms; and to treat a given area at a given rate of active ingredient.

Materials: Paper and pencil

Teaching aids: Conversion table from pounds per US or imperial gallon to kilograms per liter
Graph for determining amount of granular materials required for various plot sizes

INTRODUCTION

Insecticide recommendation rates are often expressed as kilograms of active ingredient per hectare (kg a.i./ha) or as percent concentration (% a.i.) of active ingredient in the final diluted insecticidal solution. These rates have been carefully studied and tested to give optimum results. Therefore you should apply insecticide at the correct dosage by diluting the exact amount of the concentrated form of insecticide with a predetermined volume of water or other diluent, or by spreading the exact amount of granules required over a specific area of the crop. To achieve this, it is necessary to calculate the exact amount of insecticide material needed.

PRESENTATION

A. *Common terms used in insecticide calculations*

1) Expressions of concentrations — Each insecticide possesses an *active ingredient* (a.i.), the principal chemical compound (toxicant) that acts on the insect. When in its pure form, the toxicant may be a solid or a liquid. Because the insecticide is highly toxic, the manufacturer has to dilute it before making it available to farmers.

In commercial *solid formulations (dust, wettable powder WP, and granules)*, a certain weight of the toxicant is mixed or impregnated with a certain weight of inert powders or granules. The concentration of the a.i. is thus expressed as percentage of the weight of a.i. in the total weight of the commercial solid formulation, or:

$$\% \text{ a.i. of dust, WP, or granules} = \frac{\text{weight of a.i.} \times 100}{\text{total weight of dust, WP, or granules}}$$

Examples: Sevin 85 WP means that there are 85 grams of 1-naphthyl-N-methylcarbamate in every 100 grams of commercial 85% wettable powder;

Basudin 10% granules means that for every 100 grams of the commercial Basudin granules there are 10 grams of pure diazinon or diethyl (2-isopropyl 6-methyl 4-pyrimidinyl) phosphorothioate.

In commercial *liquid formulations* (emulsifiable concentrate EC), a certain weight of the toxicant is dissolved in a certain volume of its solvent with an emulsifying agent. The concentration of the a.i. is thus expressed in two ways:

a) Percentage

$$\% \text{ a.i. in EC} = \frac{\text{weight of a.i.} \times 100}{\text{volume of EC}}$$

b) Pounds per gallon or grams per liter

Examples: Endrin 20% EC means that for every 100 cc of commercial Endrin 20% EC there are 20 grams of pure endrin or 1, 2, 3, 4, 10, 10-hexachloro 6, 7-epoxy 1, 4, 4a, 5, 6, 7, 8a-octahydro-exo-1,4 exo-5, 8-dimethanonaphthalene (or 200 grams per liter).

2. Diluent — Diluent is any liquid (water, oil) used to reduce the amount of insecticide in any concentrate or technical material to a desired lower concentration.

3. Volume of spray — The volume of spray material is affected by the size of the foliage of the crop and the size of the individual droplet deposited on the leaf. Most fruit crops having large foliage require a large or high volume of spray material in order to obtain a thorough coverage. *High-volume spray* usually requires 400 liters or more of spray material per hectare. Obviously it requires a large volume of water and suitable equipment for transporting the spray solution.

This may create a problem where water is not readily available. In such cases it may be desirable to use a low-volume spray which would require less water and reduce the transportation requirements. But with smaller volume of liquid a finer droplet size is required to get an adequate coverage of the foliage. With recent advances in the design of spray nozzles, it is possible to produce smaller droplets with sizes from 80 microns or less (1 micron = 0.001 mm) in diameter, without requiring expensive equipment.

These nozzles are capable of producing a fine deposit on leaves, thus eliminating the need for

large volume of liquid. *Low volume spray* usually denotes a spray volume of 4 liters to less than 400 liters per hectare of crop. Equipment recently developed can effectively spray 4 liters per hectare. This equipment is called *ultra low volume spray* (ULV).

Most insecticide recommendations are given in kilograms of active ingredient per hectare; in this case the volume of spray is to be determined by the type of spraying equipment available and its corresponding calibration. However, when the recommendation is given in percentage of active ingredient in the spray (i.e. percent of the weight of toxicant in the total weight of the diluted spray), the volume of spray is always specified. In summary:

If recommendation is given in:	Volume of spray is:
kg a.i./ha	dependent on sprayers and their calibrations
% a.i.	specified

4. Specific gravity — In the preparation of a spray solution, a certain quantity of solid formulations (dust, WP, or granules) is weighed. But liquid formulation (EC) cannot be conveniently weighed in the same manner. Its volume is measured instead. Therefore insecticide manufacturers always indicate on the label the concentration of their emulsifiable products. Some manufacturers, instead of giving concentration in percentage or pounds per gallon or grams per liter (see above), indicate the specific gravity of their products. In simplest terms, specific gravity is an expression of the relationship between the weight of a given volume of any liquid and the weight of an equal volume of water. Therefore when the specific gravity is known, it is possible to obtain a certain weight of a liquid by measuring a corresponding volume of this liquid. An emulsifiable liquid insecticide is "weighed" by determining its volume instead of by actually weighing it on a balance.

B. *Calculations*

As discussed above, there are two types of insecticide recommendations. Separate procedures for calculations are, therefore, required for each type.

1) When the recommendation is in percentage of active ingredient (% a.i.) This type of recommendation calls for a certain unit weight of active ingredient in 100 units weight of spray volume. For example, 0.05% Azodrin spray solution contains 0.05 gram of active Azodrin in 100 grams of spray volume. The volume of spray is therefore composed of two fractions: (1) volume of the toxicant and (2) volume of the diluent. Note that it is the weight, not the volume, of both the toxicant and the diluent that is involved in the computation of this type of recommendation. The weight of a liquid diluent is determined by multiplying its volume by its specific gravity. When water is used as diluent, its weight is approximately equal to its own volume (kg is equivalent to liter; gram is equivalent to cubic centimeter) because its specific gravity is approximately 1. Formula 1, 2, and 3 under this section are based on water as the diluent.

Conversion Tables

Pounds per US or imperial gallon to kilograms per liter

US		Imperial	
lb/US. gal	kg/liter	lb/Imp. gal	kg/liter
1	0.12	1	0.10
2	0.24	2	0.20
3	0.36	3	0.30
4	0.48	4	0.40
5	0.60	5	0.50
6	0.72	6	0.60

If an insecticide is to be diluted in oil or any liquid other than water, formulas 1, 2, and 3 should not be used. Refer to: "Scientific guide to pest control operations (2nd ed.) by L.C. Truman and W.L. Butts. Cleveland, Ohio: Pest Control Magazine, pp. 43-45."

A. *For wettable powder (WP)*

Steps	Key points
1 Assemble pertinent data	The following data must be given: a) Specified volume of spray, liters per hectare. If volume is given in gallons, multiply gallons by 3.8 to obtain liters; b) Recommended concentration (% a.i. desired); c) Concentration of the commercial WP, % a.i.
2 Compute the total weight of toxicant in the specified volume of spray	$\text{Weight of toxicant} = \frac{\text{\% a.i. desired} \times \text{specified spray volume (liters)}}{100}$
3 Compute the weight of WP to satisfy the required weight of toxicant (Formula 1)	$\text{kilograms of WP required} = \frac{\frac{\text{\% a.i. desired} \times \text{specified spray volume (liters)}}{100}}{\frac{\text{\% a.i. in commercial WP}}{100}}$ or simply $\text{WP required (kg)} = \frac{\text{\% a.i. desired} \times \text{specified spray volume (liters)}}{\text{\% a.i. in commercial WP}}$

(Instructor: Proceed to "Application" and give example to apply this formula before discussing next formula.)

B. *For emulsifiable concentrates (EC)*

Steps	Key points
1 Assemble pertinent data	The following data must be given: a) Specified volume of spray (liters per hectare). Convert gallons into liters (1 gal = 3.8 liters); b) Recommended concentration (% a.i. desired); c) Concentration of commercial emulsifiable concentrates (1) % a.i. (use formula 2 below) (2) pounds per gallon (convert to kilograms per liter before using formula 3 below)
2 Compute the total weight of toxicant to be mixed in the specified spray volume	$\text{Weight of toxicant required} = \dfrac{\text{\% a.i. desired} \times \text{specified spray volume (liters)}}{100}$
3 Compute the volume of commercial EC to satisfy the required weight of toxicant	a) **If concentration of EC is % a.i.:** $\text{Volume of toxicant required (liters)} = \dfrac{\dfrac{\text{\% a.i. desired} \times \text{specified spray volume (liters)}}{100}}{\dfrac{\text{\%a.i. in commercial EC}}{100}}$ or simply (Formula 2) $\text{liters of EC required} = \dfrac{\text{\% a.i. desired} \times \text{specified spray volume (liters)}}{\text{\% a.i. in commercial EC}}$ b) If concentration of EC is in kg a.i./liter (Formula 3) $\text{EC required (liters)} = \dfrac{\text{\% a.i. desired} \times \text{specified spray volume (liters)}}{100 \times \text{concentration (kg/liter) a.i. in commercial EC}}$

(Instructor: Proceed to "Application" and give examples to apply these formulas before discussing next formula.)

2) When the recommendation is in kilograms of active ingredient per hectare (kg a.i./ha)

A. *For wettable powders (WP), dust, and granules*

Steps	Key points
1 Assemble pertinent data	The following data must be given: a) Area to be sprayed (hectares, or square meters). Convert to kg/ha if rate is given in lb/acre (multiply lb/acre by 1.12 to obtain kg/ha). b) Concentration of toxicant in WP, dust, or granules (% a.i.); c) Recommended rate (kg a.i./ha).
2 Compute the weight of WP, dust, or granules required per hectare	$\text{Wt of WP, dust, or granules (kg)} = \frac{\text{Recommended rate (kg/ha)}}{\text{\% a.i. in WP, dust, or granules}} \times 100$
3 Compute the weight of WP, dust, or granules required per area concerned (Formula 4)	a) If area is in hectare: $\text{Wt of WP, dust, or granules required (kg)} = \frac{\text{Recommended rate (kg/ha) x Area (ha) x 100}}{\text{\% a.i. in WP, dust, or granules}}$ b) If area is in square meters: $\text{Wt of WP, dust, or granules required (kg)} = \frac{\text{Recommended rate x Area (sq m)}}{\text{\% a.i. in WP, dust, or granules x 100}}$

(Instructor: Proceed to "Application" and give examples to apply formula 4 before discussing next formula.)

B. *For emulsifiable concentrates (EC)*

Steps	Key points
1 Assemble pertinent data	The following data must be given: a) Area to be treated (hectare or square meter) b) Recommended rate (kg a.i./ha). Convert to kg/ha if rate is given in pounds per acre (multiply lb/acre by 1.12 to obtain kg/ha). c) Concentration of commercial EC (1) % a.i. use formula 5 (2) kg/liter (If concentration is given in lb/gal, first convert it to kg/liters before using formula 6. Multiply lb/gal by 0.12 to obtain kg/liter).
2 Compute the volume of commercial EC required per hectare	a) If concentration of EC is % a.i. $\text{Liters of EC per hectare} = \frac{\text{Recommended rate (kg/ha)}}{\text{\% a.i. in commercial EC}} \times 100$ b) If concentration of EC is kg a.i./liter: $\text{Liters of EC per hectare} = \frac{\text{Recommended rate (kg/ha)}}{\text{kg a.i./liter in commercial EC}}$
3 Compute the volume of commercial EC required per area concerned	a) If concentration of EC is % a.i.: (Formula 5) $\text{Liters of EC required} = \frac{\text{Recommended rate (kg/ha)} \times \text{Area (ha)} \times 100}{\text{\% a.i. in commercial EC}}$ or if area is in square meter: (Formula 5 bis) $\text{Liters of EC required} = \frac{\text{Recommended rate (kg/ha)} \times \text{Area (sq m)}}{\text{\% a.i. in commercial EC} \times 100}$ b) If concentration of EC is kg a.i./liter (Formula 6) $\text{Liters of EC required} = \frac{\text{Recommended rate (kg/ha)} \times \text{Area (ha)}}{\text{kg a.i. liter in commercial EC}}$ If area is in square meter: (Formula 6 bis) $\text{Liters of EC required} = \frac{\text{Recommended rate (kg/ha)} \times \text{Area (sq m)}}{\text{kg a.i./liter in commercial EC} \times 10{,}000}$

APPLICATION

Formula 1

$$\text{WP required (kg)} = \frac{\text{\% a.i. desired} \times \text{specified spray volume (liters)}}{\text{\% a.i. in WP}}$$

Example: To control green leafhoppers, 2,000 liters of 0.09 percent carbaryl is to be prepared. The wettable powder Sevin to be used contains 85% carbaryl. What is the required weight of Sevin?

Data given:

a) Concentration of commercial Sevin 85% a.i. WP
b) Specified spray volume = 2,000 liters
c) Recommended concentration = 0.09% a.i.

Calculation:

$$\text{Kg of Sevin} = \frac{0.09 \times 2000}{85} = 2.118 \text{ kg of Sevin 85 WP}$$

Formula 2

$$\text{Liters of EC required} = \frac{\text{\% a.i. desired} \times \text{specified spray volume (liters)}}{\text{\% a.i. in commercial EC}}$$

Example: 500 gallons of 0.04 percent endrin spray is needed to control rice stem borers. What is the volume of commercial Endrin 19.5% EC required?

Data given:

a) Concentration of commercial Endrin 19.5% EC
b) Specified spray volume = 500 gal x 3.8 liters/gal. = 1900 liters
c) Recommended concentration = 0.04% a.i.

Calculation:

$$\text{Liters of Endrin required} = \frac{0.04 \times 1900}{19.5} = 3.897 \text{ liters}$$

Formula 3

$$\text{Liters of EC required} = \frac{\text{\% a.i. desired} \times \text{specified spray volume (liters)}}{100 \times \text{kg a.i./liter in commercial EC}}$$

Example: 500 liters of 0.05% Accothion spray is to be prepared to control stem borers and leafhoppers. If Accothion 500—E, an emulsifiable concentrate containing 500 grams active ingredient per liter, is used, calculate the required volume.

Data given:

a) Concentration of Accothion 500-E = 500 g/liter = 0.5 kg/liter
b) Specified spray volume = 500 liters
c) Recommended concentration = 0.05% a.i.

Calculation:

$$\text{Liters of Accothion 500-E required} = \frac{0.05 \times 500}{100 \times 0.5} = 0.50 \text{ liters}$$

Formula 4

$$\text{Weight of WP, dust, or granules required (kg)} = \frac{\text{Recommended rate (kg/ha)} \times \text{Area (ha)} \times 100}{\text{\% a.i. in WP, dust, or granules}}$$

or

$$\text{Weight of WP, dust, or granules required (kg)} = \frac{\text{Recommended rate (kg/ha)} \times \text{Area (sq m)}}{\text{\% a.i. in WP, dust, or granules} \times 100}$$

Example: Basudin 10G granules containing 10% active ingredient is used to control pink stem borers at a rate of 2 kg a.i./ha.How many kilograms of Basudin 10G are needed for a 2,500 sq m plot?

Data given:

a) Concentration of Basudin 10G = 10% a.i.
b) Recommended rate = 2 kg a.i./ha
c) Area to be treated = 2,500 sq m

Calculation:

$$\text{Weight of Basudin 10G required} = \frac{2 \times 2500}{10 \times 100} = 5 \text{ kg}$$

Formula 5

$$\text{Liters of EC required} = \frac{\text{Recommended rate (kg/ha)} \times \text{Area (ha)} \times 100}{\%\text{ a.i. in commercial EC}}$$

or

$$\text{Liters of EC required} = \frac{\text{Recommended rate (kg/ha)} \times \text{Area (sq m)}}{\%\text{ a.i. in commercial EC} \times 100}$$

Example: When the recommendation calls for 2 kg/ha of gamma-BHC to control rice stem borers, and an emulsifiable concentrate containing 20% gamma-BHC is available, how many liters of this formulation is needed to treat 8,000 sq m?

Data given:

a) Area to be treated = 8,000 sq m
b) Concentration of commercial gamma-BHC emulsifiable concentrate: 20%
c) Recommendation: 2 kg a.i./ha

Calculation

$$\text{Liters of 20\% gamma-BHC required} = \frac{2 \times 8000}{20 \times 100} = 8 \text{ liters}$$

Formula 6

$$\text{Liters of EC required} = \frac{\text{Recommended rate (kg/ha)} \times \text{Area (ha)}}{\text{kg a.i./liter in commercial EC}}$$

or

$$\text{Liters of EC required} = \frac{\text{Recommended rate (kg/ha)} \times \text{Area (sq m)}}{\text{kg a.i./liter in commercial EC} \times 10{,}000}$$

Example: To control rice bugs and leaf folders methyl parathion should be applied at a rate of 1.5 kg a.i./ha. Folidol emulsifiable concentrate, containing 6 lb (US)/gal of methyl parathion, is available. How many liters of Folidol are needed to treat 3.5 hectares?

Data given:

a) Area to be treated = 3.5 ha
b) Recommended rate = 1.5 kg/ha
c) Concentration of methyl parathion in Folidol = 6 lb (US)/gal x 0.120
= 0.720 kg/liter

Calculation:

$$\text{Liters of Folidol required} = \frac{1.5 \times 3.5}{0.72} = 7.29 \text{ liters}$$

EVALUATION

1) Insecticide recommendations are usually expressed in two ways. What are they?
2) What is an active ingredient?
3) Explain the expression "Sevin 85% wettable powder."
4) Explain the expression "Dimecron 50% emulsifiable concentrate."
5) Explain the expression "Folidol 6 lb/gal emulsifiable concentrate."
6) What is a diluent?
7) What is a high-volume spray? And a low-volume spray? And an ultra low-volume spray?
8) How is an emulsifiable concentrate "weighed"

during the preparation of an insecticide spray? Why?

9) Explain the expression "a 0.04% Malathion spray solution."

10) Why are formulae 1, 2 and 3 not applicable to diluents other than water?

11) Commercial Sevin wettable powder contains 85% a.i. How many kilograms of this Sevin are needed to make 200 liters of 0.09% spray solution?

12) Dimecron 50 emulsifiable concentrate is to be used in controlling stem borers and whorl maggots at a rate of 1.75 kg a.i./ha. Compute the volume of Dimecron 50 needed to treat an area 1,250 sq m.

13) Accothion 500-E contains 500 g a.i. per liter of emulsifiable concentrate. An experiment with a total area of 600 sq m is to be protected against insect pests with this insecticide as a 0.05% spray solution. How many milliliters of Accothion 500-E are required to mix with 5 gallons of water to be used in a knapsack sprayer?

14) Furadan granules contain 8% a.i. How many kilograms of Furadan are required to apply to an area of 8,000 sq m at a rate of 2 kg a.i./ha?

15) Folidol contains 6 pounds/gal (US) of active ingredient as methyl parathion. How many liters of Folidol are needed to prepare sufficient spray solution to treat an area of 2.4 hectares at a rate of 1.25 kg a.i./ha?

4. APPLYING GRANULAR INSECTICIDES

Objectives: To be able to broadcast uniformly a required amount of granular insecticide over a given area at a definite time and to manage the treated area afterwards.

Materials: Each trainee will need:
500 g Dol granules
1 plastic bag or any other suitable container

Teaching aids: Slides showing a) steps involved in broadcasting of granular insecticide, and b) leaf damage due to burning by granular insecticide when applied to wet plants

INTRODUCTION

Granular insecticides, although more expensive, are easier to apply than other formulations of insecticides. They can be spread by mechanical spreaders, but for small farms, spreading by hand is a practical and economic method. Granular insecticides are used mostly in the preventive control of rice insect pests. Because of their chemical nature, they dissolve slowly in paddy water and the dissolved toxicant does not move very far from its granular carrier. Therefore you must apply granular insecticides correctly to achieve maximum benefit. This lesson teaches the skills necessary to apply granular insecticides.

PRESENTATION

Manufacturers of various granular insecticides specify the time and frequency of application of their products. Read this information which usually appears on the label; it is intended as a preventive control and has been tested for this purpose. If applied much later than the date recommended (number of days after transplanting), the effectiveness of these insecticides in preventing an insect attack will be reduced. If applied earlier, however, there is little or no harm.

When you have determined the proper time to apply the granular insecticides, proceed as follows:

Steps	Key points
1 Compute weight of granular insecticide to be applied	See "Insecticide calculations — granular insecticides."
2 Weigh the insecticide	Place the granules in a plastic bag or suitable container.
3 Check area to be treated	a) Water level in the paddy must be at least 2 cm deep. b) All levees should be closed. Check for any seepage and repair levees if necessary.
4 Broadcast the granules	See "Broadcasting granular materials" and make sure that: a) your hand is dry; b) plant leaves are not wet; c) wind is not strong; and d) your hands are washed thoroughly with soap and water after applying the insecticide.

5 Keep levees closed for at least 5 days	Do not irrigate adjacent paddies by opening a levee of the treated plot. This is a bad practice because it transfers the chemical from the treated to untreated paddies.

APPLICATION

1) Assign a paddy to each trainee group.
2) Have the trainees perform Step 1 through Step 4 using Dol granules. (See to it that trainees follow the prescribed key points, and that granules are uniformly distributed in the paddy.)

EVALUATION

1) Why do you keep all levees closed and have at least 2 cm of water in the paddy before applying granular insecticide?
2) Why should you dry your hands before broadcasting granular insecticide?
3) What may happen if granular insecticide is applied when plant leaves are wet?
4) Why is it important to apply insecticide at a frequency recommended by the manufacturer?
5) Why do you keep the levees of treated paddies closed for at least 5 days?

5. PREPARING INSECTICIDE SPRAYS

Objectives: To be able to mix insecticides in forms of wettable powders and emulsifiable concentrate in a predetermined volume of water; to use a wetting agent or a sticker whenever necessary; and to avoid mixing incompatible substances.

Materials: Each group of trainees will need:

50 g Sevin 85 WP	1 bamboo stirrer
20 ml Folidol 50%	1 scale
60 ml Shell Tenac sticker (or substitute)	1 graduated cylinder
1 container, minimum capacity 15 liters	

(Note: If a graduated cylinder and scale are not available, use a milk can, tablespoon, teaspoon, or other commonplace food containers. These containers must be previously calibrated by the instructor.)

Teaching aids: Slides showing a) caking of wettable powder insecticide; b) wettable powder floating on surface of water; c) deposits of insecticides with and without sticker; and d) compatibility chart

INTRODUCTION

After you have selected an insecticide, prepare it for application. Before using insecticides in concentrated forms, such as wettable powders (WP) or emulsifiable concentrates (EC), dilute them with the appropriate liquids, such as water and oil. Diluting insecticides properly will contribute greatly to the success of an insect control program. You will not only save time and cost but facilitate control of the insect infestation in an efficient manner. This lesson teaches the procedures for preparing insecticide sprays before applying them in the field during both the dry and wet seasons.

PRESENTATION

With new formulations of insecticide, it is rarely necessary to do more than to add the required weight of WP or volume of EC to water. Under certain special conditions, e.g. during rainy season, you may need to improve the wetting properties or the adherence of the spray deposit to rice leaves. This calls for the addition of a wetting agent (surfactant) or a sticker.

A. *Compatibility of insecticides and supplementary materials*

When using mixtures of formulations, unwanted interaction between the components may sometimes occur. This interaction may result in (a) reduction of active ingredient, (b) damage to the plant, and (c) the formation of a different chemical with an unknown residue. Wetting agents, emulsifying agents, and other forms of surfactant fall into three broad groups according to their chemistry: anionic surfactants, cationic surfactants, and non-anionic surfactants. If cationic and anionic compounds are mixed, the resulting reaction causes the acidic and basic components to precipitate into a residue, with consequent loss of desirable active components. This property of insecticides and supplementary materials is indicated on the label and can be determined by using the compatibility chart.

B. *Preparing insecticide sprays*

Steps	Key points
1 Assemble pertinent data	a) Required weight of WP or volume of EC. See "Insecticide calculations." b) Volume of water to dilute, as recommended, or as computed from "Sprayer calibrations." c) Volume of wetting agent, or sticker if required.
2 Compute the number of sprayer loads needed for the required volume of water	Divide required volume of water by volume of each sprayer load.
3 Compute the amount of insecticide required by sprayer load	Divide total amount of insecticide by the number of sprayer loads.
4 Pour 1/4 of the required volume of water into the container	a) Use clean water. b) The container should contain more than the sprayer tank. c) Never place insecticide ahead of the water because the wettable powder tends to float and many emulsifiable concentrates are acidic.
5 Measure the computed weight or volume of insecticide per sprayer load	a) Measure accurately with appropriate measuring devices. b) Remember too much insecticide is costly and may result in undesirable residue on crop; too little insecticide may not control insect effectively.
6 Add the insecticide to the water container	For wettable powder, thoroughly mix it with a small amount of water before pouring it into the water container. This facilitates dispersion of the powder in a large amount of water. Avoid spilling on skin or cloth. If this happens, wash with soap and flush skin with plenty of water.
7 Mix the insecticide	Use the bamboo stick, not your hand.
8 Add wetting agent or sticker if required	Read carefully the labels of the insecticide and the additive for their compatibility. Remember an anionic compound cannot be mixed with a cationic one.

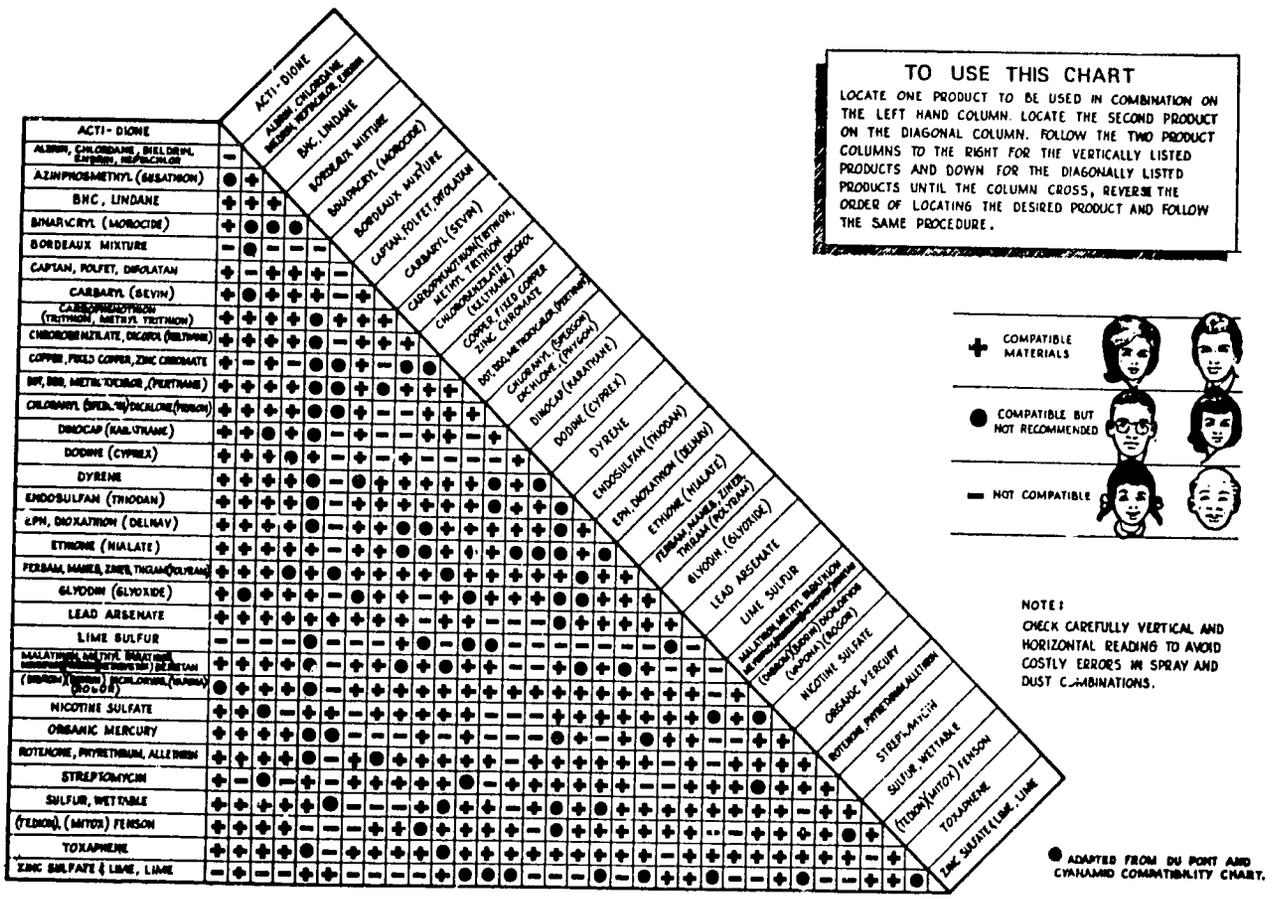
9 Stir the mixture again	Use the same stirring stick.
10 Add remaining water to complete dilution	

APPLICATION

A. Have each group of trainees mix Sevin 85 WP with enough water to fill a 15-liter knapsack sprayer. The recommendation is 1,900 liters of 0.09% Sevin per hectare.

1) First calculate the required weight of Sevin 85 WP:

$$\text{wt. of sevin needed (kg)} = \frac{\text{Volume of spray desired} \times \text{\% conc.}}{\text{\% a.i. in commercial WP}}$$



COMPATIBILITY CHART OF SPRAYING AND DUSTING MATERIALS

Preparing insecticide sprays
(From E. H. Glass, F. B. Calora, M. R. Vega, and F. C. Quebral, "A Manual of Pesticides" (College, Laguna, Philippines, University of the Philippines, College of Agriculture, 1968), p. 72.

2) Number of sprayer loads:

$$\frac{1{,}900 \text{ liters}}{15 \text{ liters/load}} = 126.6 \text{ loads}$$

3) Amount of Sevin 85 WP per load:

$$\frac{2 \text{ kg} \times 1{,}000 \text{ g/kg}}{126.6 \text{ loads}} = 15.8 \text{ g/load}$$

4) Ask the trainees to mix 15.8 g of Sevin 85 WP in 15-liters of water in a container but *not* in a sprayer, with 60 ml of Shell Tenac sticker.

B. Do the same exercise but with Folidol 50% EC. Rate 1 kg a.i./ha.

EVALUATION

(Consider the performance of the trainees satisfactory when they can prepare a uniformly mixed spray solution.)

1) Before mixing the insecticide with water, why do you measure out the required amount of insecticide with care?
2) Why don't you place the insecticide in the container before pouring water?
3) Why do you pour only part of the total amount of water before adding insecticide?
4) How do you facilitate the dispersion of WP in water?
5) How does an undesirable interaction between two substances occur?
6) What may happen if you mix two incompatible liquids?
7) When do you use a sticker?

6. SPRAYING INSECTICIDES

Objectives: To be able to apply foliar sprays of insecticide correctly and to minimize the hazards in doing the job.

Materials: Each group of trainees will need:
1 knapsack or compressed-air sprayer calibrated previously
Water for dilution and cleaning purposes

Teaching aids: Overhead projector transparencies showing wind directions and corresponding spraying methods
Slides showing the spraying of a ricefield

INTRODUCTION

In protecting rice crops against insect pests, it is sometimes necessary to apply a small amount of insecticides over the surface of the rice plant. Spraying with foliar insecticides is thus a much more difficult task than broadcasting of granular insecticide, but spraying destroys more insects at various stages of development, except stem borer larvae. A number of precautions should be observed when spraying insecticides. This lesson is designed to help the trainees identify the problems in spraying insecticides and to minimize the chances of damage due to mishandling.

PRESENTATION

After identifying the insects causing or likely to cause damage to your rice crop and selecting the appropriate insecticide, determine when to spray. Next it is necessary to determine the area to be treated and the volume of spray (see "Sprayer calibration") to be used and, finally, prepare the spray solution. In carrying out the spraying operation, follow the procedure outlined below:

Steps	Key points
1 Check the weather	a) Spray during a sunny day. b) Check wind direction to prevent damage from spray drift.
2 Have spraying equipment ready	a) Pump the tank and check other parts according to manufacturer's instructions. b) Pour the prepared spray solution into a spray tank.
3 Read the label once more	a) Recheck the dosage rate recommended; b) Note the safety precautions; c) Note the interval that must elapse between applying and harvesting the crop.
4 Wear protective clothing	Every item written on the label is a result of extensive research. Strictly follow instructions for the safety of your own health and of others.

5 Start spraying	a) Avoid spray drift. Spray only when there is no wind toward another crop. b) When treatment is necessary in windy weather, spray downward as this causes slightly less drift than spraying upwind or crosswind. c) Keep the distance between the nozzle and ground level constant. d) Walk at a constant speed. e) Shake the spray tank frequently to keep wettable powder or emulsifiable concentrate in suspension. f) Pump the tank regularly to keep pressure constant. g) Do not smoke while spraying.
6 Wash the spray tank	a) Dispose of the excess amount of insecticide solution in the spray tank properly (see "Handling insecticides"). b) Wash as directed in "Preparing the sprayer for storage."
7 Remove protective clothing and wash hands	Wash thoroughly with soap immediately after working with insecticide and before eating, drinking, or smoking.

APPLICATION

1) Assign the trainees a crop area, preferably one having some insect damage.
2) Assist the trainees in selecting the appropriate insecticide to be used.
3) The trainees will perform all necessary steps in spraying. Check trainees' performance according to described key points.
4) Inspect the treated field daily with the trainees and note the effect of spraying.

EVALUATION

1) Why is the spraying of insecticides one of the most difficult jobs in farm operations?
2) What information do you need to know before considering spraying?
3) Why should you prefer to spray a foliar insecticide on a sunny day?
4) Why should you read the label before spraying?
5) Describe how to avoid spray drift.
6) If WP or EC is used, why should the spray tank be shaken frequently?
7) Why pump the spray tank regularly while spraying?
8) What is the importance of keeping the distance between the nozzle and the ground level, and walking speed constant while spraying?

7. STORAGE, HANDLING, AND DISPOSITION OF INSECTICIDES

Objectives: To be able to dispose of diluted insecticidal solutions and empty insecticide containers; to demonstrate how to store insecticides; and to be able to follow the safety code for handling agricultural chemicals.

Materials: An empty insecticide bottle, and other available insecticide containers

Teaching aids: Slides showing storage of insecticides

INTRODUCTION

All insecticides are poisons. They are made to kill harmful insects. However, if misused, they may also harm fish and farm animals in the area where they are being applied. There are many ways in which insecticides may be mishandled. Therefore one should be aware of precautions to observe in handling insecticides.

PRESENTATION

A. *Disposal of diluted insecticidal solutions*

Any insecticidal solution that remains after a spraying job should be sprayed onto waste land where it will not be harmful. Select an area for this purpose. Never drain it into a stream or in irrigation or drainage canals. Many farmers raise fish, ducks, and chicken in or around their farms. These animals may be poisoned by improperly handled insecticides.

B. *Disposal of insecticide containers*

Insecticide formulations are marketed in different kinds of containers. All empty containers should be disposed of safely as follows:

a) Glass and metal containers. Wash out the insecticides and add the washings to the spray tank *before* completely filling the tank with water. Store the washed container in a safe place. Punch holes into metal containers to prevent their re-use, and give or sell them to a metal merchant.

b) Cardboard boxes, paper sacks, polyethylene bags, and similar packs. Burn the containers and bury the ashes.

C. *Storing insecticides*[1/]

a) Store all insecticides in original containers and in a locked closet, out of reach of children, pets, or livestock.

b) Never transfer insecticide to other containers.

c) Keep all insecticides away from food and foodstuffs.

d) Discard any insecticide container without label or with damaged labels. Do not guess at contents.

e) Avoid exposing insecticides to extremes of temperatures and to high humidity. High and low temperatures affect herbicide formulations, particularly the wettable powders and granules, thus resulting in decomposition hazards. High humidity may cause caking of solid products like wettable powders, dust, and granules.

f) Make certain that partly used containers are tightly closed and clearly labelled.

g) If spraying is to be stopped because of a change in the weather, any unused diluted materials should be removed from the sprayer and stored temporarily in a suitable noncorrosible container, clearly labelled with the name of the chemical, the extent to which it has been diluted, and the date of preparation.

1/ Reproduced from Pesticide Handbook-Entoma, by permission of College Science Publishers, State College, Pa., U.S.A. and from Weed Control Handbook, by permission of Blackwell Scientific Publications Ltd., Oxford, England.

Safety code for handling agricultural chemicals[2/]

a) Always read the label on chemicals before using sprays or dust. Note warnings and cautions each time before opening the container.

b) Keep sprays and dusts out of the reach of children, pets, and irresponsible people. They should be stored outside of the home, away from food and feed. (Herbicides should not be stored near seeds.)

c) Always store sprays and dusts in original containers and keep them tightly closed. Never keep them in anything but the original container.

d) Never smoke while spraying or dusting.

e) Avoid inhaling sprays or dusts. When directed on label, wear protective clothing or masks.

f) Do not spill sprays or dusts on the skin or clothing. If they are spilled, remove contaminated clothing immediately and wash thoroughly.

g) Wash hands and face and change to clean clothing after spraying or dusting. Also wash clothing each day before re-use.

h) Cover food and water containers when treating livestock or pet areas. Do not contaminate fishponds.

i) Use separate equipment for applying hormone-type herbicides in order to avoid accidental injury to susceptible plants.

j) Always dispose of empty containers so they cannot harm humans, animals, or valuable plants.

k) Observe label directions and cautions to keep residues on edible portions of plants within the limit permitted by law.

l) If symptoms of illness occur during or shortly after spraying or dusting, call a physician or get the patient to a hospital immediately.

[2/]The Philippine Pest Control Council issued such materials in 1975.

APPLICATION

Give the trainees a chance to apply the information on the handling of herbicides when they actually prepare the spray solution and complete a spraying operation.

EVALUATION

1) Why should a diluted insecticidal solution not be poured into streams?
2) Describe the steps involved in disposing of a) liquid insecticide containers, and b) containers for solid formulations.
3) In what ways do high humidity and temperature affect stored insecticides?
4) Why should insecticides be stored only in the original bottle?
5) It is always necessary to read the label before using insecticides; what information should you look for?
6) Cite five precautions in storing insecticides.
7) Cite at least six items in the Safety Code for Handling Agricultural Chemicals.

8. EMERGENCY TREATMENTS FOR POISONING BY PESTICIDES[1/]

Objectives: To be able to give proper remedial action quickly to persons poisoned by pesticides; to be able to induce vomiting without causing further harm to the patient; and to be able to identify the antidotes of various pesticides.

Materials: Sample of antidote of diazinon
Sample of antidote of gamma-BHC

Teaching aids: Slides showing a) bottles of soft drinks containing insecticide, and b) steps in artificial respiration

INTRODUCTION

In using agricultural chemicals, *READING THE LABEL* is of utmost importance. In spite of all the warnings and cautions indicated on the label, poisonings of individuals still do occur because of mechanical accidents or carelessness. Poisoning may also be caused when the pesticide is mistaken for some harmless substances as may happen when the pesticide is stored improperly in soft drink bottles.

Regardless of how the poisoning occurs, remedial action should be taken immediately. Many lives have been saved by proper remedial action applied quickly and expertly.

PRESENTATION

When poisoning occurs:

A. First alternative: CALL A PHYSICIAN if one can be reached easily. Describe the condition of the patient, and if known, the nature of the poison and whether it was swallowed, inhaled, or spilled on the skin. The doctor will advise what to do until he arrives.

B. Second alternative: If you cannot reach a physician, the first thing to do is to REMOVE THE CAUSE OF THE POISONING.

1/Comprehensive materials were developed in the Philippines at the 1975 Pesticide Management Conference. IRRI staff attended. Reports are in the IRRI Library.

Case 1. *If the poison has been swallowed:*

Steps	Key points
1 Induce vomiting	Put a finger or a tongue depressor down the patient's throat until he vomits. *Never try to make an unconscious person vomit.*
2 Soothe the throat and stomach and irritated membranes	Give raw eggs, milk or a thin flour paste after the stomach has been emptied. These also serve to absorb poisons.
3 Give an appropriate antidote*	Read the label for specific antidote. In general: a) *For chlorinated hydrocarbon insecticide:* perform a gastric lavage, and give saline laxative. The physician may give phenobarbital or pentobarbital to control convulsions. b) *For organophosphorus insecticides:* give atropine sulfate or Protopam chloride (also known as pralidoxime chloride and 2-PAM).

* Antidote is a substance that relieves, prevents, or counteracts the insecticide concerned.

Case 2. *If the poison has been inhaled:*

Steps	Key points
1 Remove patient to open air	Wear a mask if entering spray area.
2 Give artificial respiration	Do this only if patient is not breathing. Mouth-to-mouth suction is quickest.
3 Give appropriate antidote	See above.

Case 3. *If the poison has been spilled on skin or clothing.*
Remove contaminated clothing and wash skin with soap and plenty of water.

APPLICATION

Have the trainees practice these procedures among themselves by pretending that one has been poisoned through swallowing diazinon, and another through inhaling gamma-BHC.

EVALUATION

1) List the important facts to give a physician when reporting a case of poisoning.
2) Describe the steps in treating a person who has swallowed an insecticide.
3) Describe the steps in treating a person who has inhaled an insecticide.

8. DISEASE CONTROL

CONTROLLING DISEASES OF RICE

Objectives: To be able to describe the various ways rice diseases are spread and to indicate possible control measures.

Materials: (Any appropriate chemical to treat a rice disease occurring about the time this lesson is given.)

Teaching aids: Slides illustrating a) the dissemination of plant diseases; b) the disease cycle; and c) the approaches to disease control

INTRODUCTION

Diseases cause large losses in both the quality and the quantity of rice produced. Environmental conditions, such as high humidity and favorable temperature, enhance the rapid development and spread of organisms causing diseases. The disease-causing organisms are fungi, bacteria, viruses, and nematodes. Whenever a disease is identified, either by observation of field symptoms or by examination in the laboratory, appropriate control measures should be taken to stop further spread of the organism or to prevent it from occurring in the next cropping season. To be able to apply control measures intelligently, the farmer should know how the diseases of rice are spread. This lesson is designed to describe the various ways and conditions under which diseases are spread and the approaches to disease control.

PRESENTATION

A. *How does the plant get a disease?*

Most organisms that cause diseases in plants occur at regular intervals. The disease cycle proceeds in the following order:

1) Inoculation: The introduction of an infectious organism called inoculum into plant tissues, either in the seed or seedlings.

2) Infection: If the plant is susceptible, the organism invades and attacks the plant tissues. The plant may remain healthy if it is resistant to the organism, if the organism is ineffective, or if the carrier of the organism avoids the plant.

3) Incubation. If temperature is favorable, humidity high, and host plant well nourished, the organism develops and increases in number, and feeds on the plant tissues. Plant tissues are thus damaged and disease symptoms characteristic of that particular causal organism appear.

4) Death of plant: When plant tissues are killed, the plant dies.

5) Saprophytic phase: The organism now remains stationary in the soil and obtains food by absorbing decayed organic material. It will become active again when conditions are favorable and a good source of food becomes available during the next cropping season.

During its saprophytic phase, the inoculum may live in the tissues of certain weed plants. These plants are called intermediate host plants. Each infectious organism usually has a wide range of host plants in addition to rice.

B. *How does an inoculum spread?*

Before the infectious organism, or inoculum, becomes a saprophyte in the soil, how does it find its way into the field? Plant pathologists list the following as disseminators of inoculum:

Wind, which disseminates fungus spores (blast, sheath blight)

Water, which carries bacteria, also sclerotia, spores, and nematodes.

Soil, the breeding place of nematodes, sclerotia, also of bacteria, mycelia, and spores.

Insects which carry viruses, bacteria, and fungus spores.

Large animals which carry a variety of organisms externally and in manure.

Men, who may bring with them soil containing causal organisms or diseased plant parts, like seed, seedlings, straws, fruit, etc.

C. *How can diseases be controlled?*

Knowing how a plant becomes infected with a disease and how an infectious inoculum is transported to the plant environment, one can intelligently take appropriate measures to prevent or control diseases. Generally, the incidence of diseases can be reduced in: (1) the cultural approach or (2) the use of chemical to prevent or control the diseases; (3) varietal resistance.

1. *Cultural control*

Steps	Key points
1 Use resistant rice variety	a) Identify the diseases likely to occur in your region, based on experience from previous harvests. (For identification, see references at the end of this lesson). b) Select a rice variety resistant to most destructive diseases, particularly the hard-to-cure ones like blast, sheath blight, stem rot. Consider its resistance to insect pests, also. c) Be aware that a variety resistant to one race of an organism may be susceptible to another race of this same organism.
2 Improve soil condition	a) Soil deficient in potash favors brown spot disease. b) Too much nitrogen favors the development of fungus diseases such as blast.
3 Manage water level	Too deep (more than 10 cm) water level favors stem rot and blight diseases.
4 Destroy weeds around the farm	Cut and burn weeds to eliminate host plants of infectious organisms.
5 Take care of seedlings	a) A dry seedbed encourages blast occurrence. b) Spray seedbed with appropriate insecticides and fungicides.
6 Treat seed with chemicals	In Japan and Taiwan for example, foot rot and nematode damage are successfully reduced by treating seed with organo-mercuric compounds.
7 Reduce the number of insect vectors	Use appropriate insecticides. This is an indirect way of preventing virus diseases from occurring.
8 Burn stubble of infected plants	After harvest, or after uprooting infected plants, burn the stubble to kill or eradicate sources of inoculum.
9 Rotate crops	Do this only in case of serious damage by nematodes, for example.

2. *Chemical control*

After all cultural measures have been taken, it is unlikely that serious disease attacks will occur. However, if an unexpected outbreak of disease does occur, protect your crop immediately. Protective control calls for the application of pesticides, such as fungicides, insecticides, etc. In using fungicides, consider the following factors:

a) Cost of chemical: Certain fungicides are so expensive that it is not profitable to use them except to avoid total loss.

b) Climatic conditions: When favorable climatic conditions, such as optimum temperature and relative humidity required by the organism concerned, are present in the region, fungicides may not be able to overcome the rapid growth of the organisms. Rainy weather also renders sprayed materials less effective. Plant pathologists are selecting systemic fungicides to combat serious diseases in rice like blast *(Pyricularia oryzae)* that may be used in adverse weather.

APPLICATION

Have the trainees apply the information on cultural method for disease control when they grow their applied research rice crops. Chemical control may be feasible under certain conditions.

EVALUATION

1) What conditions favor rapid development and spread of harmful organisms?
2) Cite four major organisms causing diseases in rice.
3) How does the plant get a disease?
4) What are the six ways by which an infectious organism may be disseminated?
5) What is the importance of planting a resistant variety?
6) What is meant by "improving soil condition" in cultural control of rice diseases?
7) What is the effect of deep water in terms of disease control in rice?
8) One way of practicing field sanitation is to destroy all weeds around the farm. What is its advantage?
9) How do you indirectly prevent infestation of virus diseases?
10) When is burning of stubble advisable?
11) When is seed treatment advisable?
12) When do you recommend chemical control for diseases in rice?
13) Discuss the two important factors when considering disease control by chemicals.

Suggested further readings:

Feakin, Susan D. (Ed.). 1970. Pest control in rice. PANS Manual no. 3 p. 39-107. The Ministry of Overseas Development, London.

Ou, S.H., and F.L. Nuque. 1970. Fungus and bacterial diseases of rice. p. 217-227. *In* Rice Production Manual (Revised edition 1970), University of the Philippines, Laguna, Philippines.

Ling, K.C. 1970. Virus diseases of rice. p. 228-236. *In* Rice Production Manual (Revised edition 1970), University of the Philippines, Laguna, Philippines.

9. HARVESTING AND PROCESSING OF GRAIN

1. HARVESTING

Objectives: To be able to determine when to harvest, and to be able to harvest the rice crop.

Materials: one sickle per trainee

Teaching aids: A sample of panicles with grains ready to harvest; overripe grains and too-green grains
Slides showing steps on harvesting, hauling, and piling

INTRODUCTION

When harvesting is not done on time, grain may be lost due to damage by rats, birds, insects, shattering and lodging. Timely harvesting ensures optimum grain quality, higher market, and consumer acceptance, since the grain is less likely to break when milled. It also keeps seed dormancy within safe limits. With weakly dormant varieties, the longer the grain remains in the field, the more likely it is that it will germinate on the panicle or while in stacks awaiting threshing. The farmers therefore should know the optimum time to harvest their crops.

PRESENTATION

Task 1: *Determining when to harvest*

Most improved rice varieties are slightly photoperiod-sensitive, that is, their growing period may vary within 5 to 15 days according to the time of year they are planted. This variation in length of growing period is caused by day-length, temperature, rainfall, available sunlight, and cultural practices. However, the average growing period of a variety may serve as a guide in deciding when to harvest. As harvest time approaches you should:

Steps	Key points
1 Drain the field	a) Do this 7 to 10 days before the expected harvest date, or when the upper grains in most of the tillers are in the hard dough stage and turning from green to yellowish. b) Draining hastens maturity and improves the harvesting condition. However, denitrification would certainly occur upon reflooding in preparation for the succeeding crop.
2 Inspect the grains on the upper portion of the panicles	a) Observe the field daily. b) Select the most mature tillers. c) Dehull a few grains and observe their translucence and firmness. Grains when ready for harvest are clear and firm. The upper portion (80%) of the panicle should be straw colored.
3 Inspect the grains at the base of the panicles	a) Observe from the same tiller as above. b) When most grains at the base are in hard dough stage, the panicles are ready to be harvested.

Note: When a rice crop is ready for harvest, the stems and leaves are usually straw colored.

Task 2: *Harvesting*

When 80 percent of the panicles are straw colored and the grains in the lower portions (20 percent) are in hard dough stage, you should harvest the crop:

Steps	Key points
1 Grasp a whole hill of plants	a) Hold plants about 20 cm from the base. b) Hold them so that your thumb is on the side toward you.
2 Cut the plants and place the handful of plants on the stubble	a) Start from the left side of the field facing you. b) With the sickle in your right hand, cut the plants in the hill in one stroke. c) Place the sharp edge of the blade on the stems from the point where your hand is holding the plants to avoid cutting your left hand. d) With the hand holding the cut hill, combine the cut plants with those of the hill on the right and cut the latter in the same manner. e) Continue cutting until your hand is full. f) Move to the next row as you finish cutting a handful.
3 Haul the harvested stems	a) If weather permits, leave the handfuls of cut stems in position as they were harvested and let them dry for 1 or 2 days. b) After cutting all the hills in the plot, combine several handfuls of stems at a time and bring them to the place where threshing will be done. Arrange all panicle ends in one direction.
4 Pile harvested stems	a) If threshing cannot be done immediately, the harvested rice stems should be bundled and stacked in a dry place. Bundling will facilitate circulation of air around and through the stack, thus preventing excessive heating caused by decomposition of the harvested plants. b) If a round stack is made, place the panicle ends toward the center. If a cubical stack is made, pile only two bundles wide with panicles end to end. In both cases, the grains are better protected from rats, birds, and other farm animals. c) Protect the pile from rain.

APPLICATION

The trainees will observe and determine when to harvest the crops on a number of plots shown by the instructor. Each trainee will harvest a portion of an assigned plot, haul the harvested stems, and pile them near a thresher.

EVALUATION

1) List three benefits of timely harvesting.
2) What is likely to occur when a mature crop is left standing on the field?
3) Is the knowledge of growth duration of a certain variety a very reliable guide in determining the harvesting date?
4) When observing the panicle to determine the time to harvest what do you look for in the upper portion and at the base of the panicles?
5) Should you wait until all rice stems and leaves turn yellowish before harvesting?
6) When piling newly harvested rice what should you avoid? How can you avoid it?

2. THRESHING

Objective: To be able to separate rice grains from panicles without unnecessary scattering using a whacking frame, a pedal thresher, and an IRRI axial flow thresher.

Materials:
1 whacking frame
1 pedal thresher
1 IRRI axial flow thresher
1 canvas, at least 4 x 4 meters
1 sack

Teaching aids: Slides showing threshing operation

PREPARATION

The potential yield of a rice crop may be reduced by grain losses through careless threshing. This happens when good grains are allowed to remain on the panicles. In addition, improper threshing may cause grain scattering. You can save time in gathering scattered grains by correct threshing. On the other hand, threshing can be a problem when there is a bountiful harvest and few available laborers. The use of the pedal thresher and the IRRI axial flow thresher can solve part of this problem.

PRESENTATION

Task 1: *Threshing with a whacking frame*

Steps	Key points
1 Pile the bundles	a) Place on dry level ground. b) Arrange stalks — panicles on one side and base on the other.
2 Lay the mat or canvas on the ground	Canvas should be large enough to avoid spillage.
3 Set the whacking frame	a) Set the frame in the middle of the mat. b) Provide leeway and space for movement in handling the cut stalks.
4 Place a canvas guard on the whacking frame	Cover all sides of the frame to prevent spillage.
5 Take a bundle	a) Hold stalks near the base for leverage. b) Size of bundle should be sufficient for person to hold.
6 Whack the bundle on the floor of the frame	a) Hold the bundle firmly and in a swinging motion beat it hard against the frame. b) *Shake bundle after whacking to insure that separated grains fall on the canvas.* c) Threshing is completed when all rice grains are separated from the panicle.
7 Throw straw on one side	

Task 2: *Using the pedal thresher*

Steps	Key points
1 Arrange cut stalks in stack	Panicle should be on one side and base on the other.
2 Lay canvas beside the stack	Canvas should be large enough to avoid spillage.
3 Place the pedal thresher	a) Place the thresher on the canvas. b) Place a canvas guard on the back of the thresher to prevent seeds from scattering.
4 Take a handful of cut stalks	Hold the stalks firmly by the base.
5 Pedal the thresher	a) Place one foot on the pedal and push back and forth. b) Make sure the drum is rotating *away* from you.
6 Thresh the rice	Rotate the straws on the drum until panicles are clear of grains.
7 Place straw to the side after threshing	

Note: The operation is conveniently carried out by two or more persons threshing alternately so that the drum is rotated continuously.

Task 3: *Threshing with an IRRI axial flow thresher*

Steps	Key points
1 Place the axial flow thresher	Position the thresher so that there is space about 1 meter wide between the thresher and the stack of rice to give room for easy movement.
2 Start the motor of the thresher	a) Follow motor instructions in starting. b) Operate the thresher for a few minutes to remove dirt and other seeds retained in the thresher. This will ensure the purity of the seed being threshed.
3 Place a container at the outlet of the thresher	Do this only after all dirt and foreign seeds are allowed to drop out of the drum.
4 Take a handful of stalks	Hold the bundle near the base or cut end.
5 Feed the handful of stalks into the thresher	Release the bundle of stalks into the thresher to completely separate all the grains from the stalks.
6 Pile the straw on the backside	The straw is released and piled automatically on the backside of the thresher.
7 Stop motor after finishing threshing	When all rice stalks have been threshed, let the thresher operate for a few minutes to allow all remaining seed or straw to be removed, then stop the engine.

Note: The IRRI drum thresher provides sufficient room for up to 4 persons to work at the same time.

APPLICATION

Have the trainees thresh harvested rice with a whacking frame, a pedal thresher, and an IRRI axial flow thresher.

EVALUATION

1) Observe the straw discarded by the trainees and check whether ripe grains are present.
2) See that no grain scattering occurs.

3. DRYING THE HARVESTED PADDY[1/]

Objectives: To be able to recognize the importance of reducing moisture content of harvested paddy to 14 percent before milling or storage; to prevent stress-cracking in the field during drying and storage; and to compare sun-drying with mechanical drying.

Teaching aids: Slides showing sun-drying and mechanical drying
Slides showing diagrams of batch-type and continuous flow type of driers

INTRODUCTION

Although the milling recovery of a rice stock is affected partly by the kind of milling equipment used, it also depends greatly on the moisture content of the grain at the time of milling and on how the grain was dried. Milled rice that contains more whole grain (head rice) and less brokens has better quality and commands a higher price. Even though the domestic market in most rice producing countries may be contented with a fair mixture of whole grain and large brokens, the export market requires a high percentage of whole grain. The paddy dryer should therefore aim at a high percentage of head rice to

a) reduce losses during milling
b) preserve nutrient value, texture, and appearance
c) reduce pest damage after milling, and
d) make the export of surplus rice a real possibility.

Furthermore, the same drying conditions also ensure a high percentage of seed germination. Thus the farmer should do whatever he can to achieve those aims. He may not have control over the mechanical drying system but there are many things he can do while the grain is still in the field or in storage.

PRESENTATION

A. *Principles of grain drying*

The moisture content of the rice grain, like that of other cereal grains, changes according to the relative humidity of the surrounding air. If the surrounding air is saturated (=100% relative humidity) it can hold no more water and therefore cannot take up any water from the grain. But if the relative humidity of the air is only 75 percent, for example, it will absorb water from the grain until the grain moisture content is about 14 percent. Then, if the relative humidity of the air increases to 90 percent, the grain will absorb moisture from the air until its moisture content reaches 18 percent. The drying of grain depends upon this natural balance between relative humidity of the air and the moisture content of the grain. The grain moisture content will adjust itself to balance a given relative humidity of the air.

B. *Methods of drying*

1. In *sun-drying*, the relative humidity of the hot air in the afternoon of a clear, bright day may go down as low as 45 percent. In addition to this, the paddy is spread out as a thin layer for drying. Therefore it takes only about 2 hours to dry paddy to 14 percent moisture content (% M.C.) from an original moisture content of 25 percent.

2. *Mechanical drying* involves heating the air to reduce its relative humidity. This heated air is then passed through the paddy for a certain time to allow the grain moisture to reach an equilibrium with the air. Generally mechanical driers designed to employ this heated air principle are classified into two types:

a) *Batch type drier*, which dries one batch of grain at a time. It may be a deep bed drier (Fig. 1) or a flat bed drier (Fig. 2).

b) *Continuous flow drier*, a columnar structure which dries grain continuously and slowly.

Sun-dried or mechanically dried grain should reach a uniform optimum moisture content of 13.5 to 14%. As little as 1 percent more or 1 percent less than this optimum figure significantly reduces the recovery of head rice. Sun drying usually dries grain uniformly at optimum moisture content. But

1/ Partly adapted from D. B. de Padua, "Basic principles in grain drying", Rice Production Manual pp. 247-249, UPCA, Philippines.

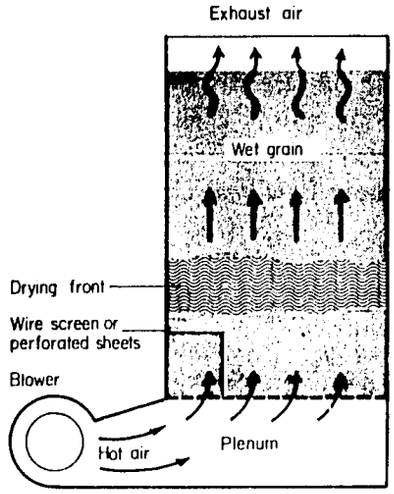


Fig. 1. Diagram of a deep bed drier.

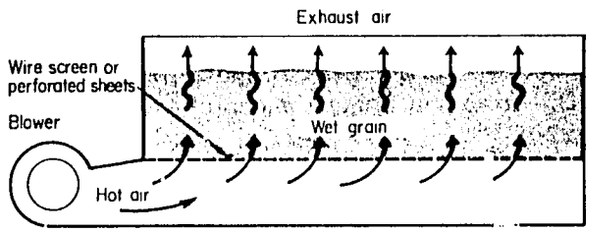


Fig. 2. Diagram of a flat bed drier.

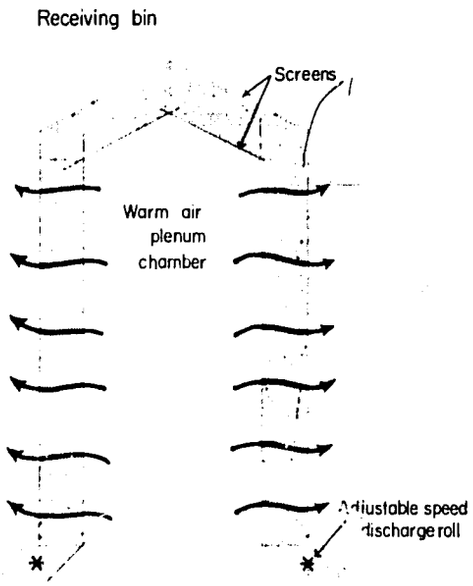


Fig. 3. Diagram of a continuous flow drier.

when rice yields increase rapidly and there is not enough space for sun drying, especially during rainy season, farmers must rely on mechanical drying. It is not easy to dry a large amount of grain mechanically to 14 percent moisture content. During drying, the moisture evaporates from the surface of the grain. This means that the outer surface is the first to dry. Considerable time must be provided to allow the moisture in the center of the grain to diffuse to the grain's surface. Some drying systems use two or three tempering bins to achieve this purpose so that grain can be dried uniformly. The tempering period varies from 4 to 8 hours depending on the drying temperature. If the drying temperature is moderate (about 38°C), the internal moisture diffusion during drying does not

lag greatly behind the rate of surface evaporation, and the tempering period will consequently be short. On the other hand, at a temperature of 60°C, the relative humidity of air is reduced to only about 20 percent. The surface evaporation exceeds the internal water diffusion, and the outside of the grain dries excessively and shrinks. This causes internal stresses and cracking of the unmilled grain. The cracking of the paddy kernels may occur while they are still in the field or in storage awaiting drying or milling because moisture is absorbed quickly during the night and evaporates quickly during day time.

3. *Preventing stress cracking*

To ensure a higher head rice yield, stress cracking of rice kernels in the field during drying or during storage should therefore be prevented.

Task 1: *Preventing stress cracking in the field*

Steps	Key points
1 Harvest the crop at the right time	a) Refer to lesson on "Harvesting." b) When 80 percent of a panicle is straw colored, the average moisture content of the grain is about 20 percent. Harvesting at this time ensures grain maturity, relatively easy threshing, and less stress cracking because the starchy kernel is still plastic.
2 Thresh the harvested rice as soon as possible	a) Refer to lesson on "Threshing." b) Piling harvested rice in bundles and leaving it in the field for several days favors excessive absorption and evaporation of moisture from the grain, especially during dry season. This causes stress cracking.
3 Dry the paddy as soon as possible	a) Remember that harvested grains are living organisms. They continuously respire as long as they have sufficient moisture. In other words wet grain will deteriorate rapidly. b) Use a suitable method of drying (see Task 2).

Task 2: *Preventing stress cracking during drying*

Good milling quality, can be obtained through periods of moderate evaporation alternating with tempering periods. This can be achieved by passing through the wet grain a high air flow (20 cu ft of air per minute per cu ft of grain) that has been heated to 38°C. Three evaporation periods with two tempering periods reduce the moisture content from 25 percent to 14 percent in 20 hours.

Task 3: *Preventing stress cracking during storage*

After the grain has been dried to 13.5 to 14 percent, it will again absorb a considerable amount of moisture if improperly stored. See "Storing rice" for details.

APPLICATION

Visit a flat bed drier and a columnar drier installation. The instructor or the drying plant personnel will explain the operation of these driers.

EVALUATION

1) Explain the three important objectives of drying paddy.
2) How is grain dried?
3) What is moisture equilibrium?
4) Cite two factors causing low head rice yield.
5) What causes stress cracking of rice kernels? When would it occur?
6) How can farmers prevent stress cracking in the field?
7) How do engineers reduce cracking during the drying process?

4. DETERMINING GRAIN MOISTURE[1/]

Objectives: To be able to describe the different methods of determining moisture content, to be able to determine the moisture content of paddy by using an air oven and the oil immersion method.

Materials:
- 1 laboratory air oven
- 1 laboratory thermometer, capacity 250°C
- 1 container (tumbler, or a tall tin can) equipped with an iron wire to hold the thermometer
- 1 wire net, with meshes smaller than the size of rice grain cut to fit the diameter of the container
- 200 ml of vegetable cooking oil
- 1 pair of pliers
- 1 stove or other heating device
- 1 balance or scale capable of weighing to 0.1 or lower
- 2-kg sample of paddy for testing

INTRODUCTION

The moisture content of the grain greatly affects the quality of the harvested rice (paddy) both during storage and in milling. Rice with a moisture content more than 14 percent should not be stored over a long period. Large amounts of moisture within the grain help increase its biological changes, thus favoring rapid deterioration of the product. On the other hand, moisture contents higher or lower than 14 percent will result in more broken grains when milled. The farmer should therefore make sure that his paddy has the right moisture content when stored or milled.

There are several methods of determining the amount of moisture in grain. The *direct method* using an air oven and Brown Duvel fractional distillation are time consuming and not suitable for practical purposes. Other methods measure the moisture content indirectly by using the electrical properties of the rice grain. The Universal, the Safecrop, and the Steinlite moisture testers use this method. When placed between two capacitor plates, the grain affects the capacitance of the meter according to the amount of grain moisture, the degree of compaction, and grain temperature. These electronic moisture testers are expensive, however.

This lesson describes a standard method for determining the moisture content of grain with a rapid method using cooking oil.

1/ Partly adapted from Office of Rural Development, "Simplified moisture determination method" (Manila: U. S. Agency for International Development, 1970).

The oil immersion method

Steps	Key points
1 Weigh sample of paddy	a) Use properly sampled paddy. b) Mix sample well before weighing. c) Weigh sample to any convenient quantity, preferably 100 g, to simplify calculations. d) Record weights in grams.
2 Place sample in container	a) Use a tall heat-resistant container. DO NOT USE A FLAT CONTAINER AS IT COMPLICATES INSTALLATION OF THERMOMETER. b) Place a wire netting over the seed to prevent seed from overflowing during boiling.
3 Pour oil into container	a) Any available cooking oil is suitable as long as it has no trace of water. b) Use only enough oil to cover the seed. TOO MUCH OIL WILL PROLONG HEATING TIME.
4 Install thermometer	a) Use a thermometer that can measure temperatures up to 250°C b) Place an iron wire over the mouth of the container to hold the thermometer erect. c) Make sure that the seed covers the thermometer bulb.
5 Weigh the entire apparatus (initial weight)	a) Use the same balance used in Step 1. b) Include the weights of the container, oil, seed, wire netting, iron wire, and thermometer. c) Record the weight in grams.
6 Light the stove	
7 Heat the entire apparatus	a) Place the apparatus on a stove or any available heating device. b) Watch closely the rise in temperature on the thermometer. c) With a pair of pliers remove apparatus from stove immediately when temperature reaches 190°C. d) DO NOT STOP HEATING IF TEMPERATURE IS BELOW 190°C AS COMPLETE MOISTURE EVAPORATION IS ACCOMPLISHED ONLY AT 190°C OR ABOVE.
8 Weigh the entire apparatus again (final weight)	a) Repeat step 5. b) Record final weight in grams.

9
Compute the moisture content

a) Weight lost between initial and final weighing is the amount of moisture contained in the sample:

$$\text{Percent moisture content (wet basis)} = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

b) If sample weight is 100 g, percent moisture content is simply =

Initial weight (g) - Final weight (g)

c) The result is more reliable if at least two determinations are made.

APPLICATION

With the trainees divided into four groups

1) Groups I and II: Work on steinlite or safecrop moisture tester.
2) Groups III and IV: Work on the oil immersion method using seed from the same source.
3) Report the moisture contents to the nearest 0.01 percent.
4) Compare the results of the oil immersion method with those of the steinlite or safecrop moisture tester.

EVALUATION

1) Why is it important to determine the moisture content of paddy before storage and milling?
2) Cite four methods of determining grain moisture.
3) The steinlite moisture meter gives the most reliable result, but it is not practical. Why?
4) In the oil immersion method why is a tall metal container preferred?
5) What temperature should the boiling oil attain? Why is the temperature critical?
6) How does moisture content (wet basis) differ from moisture content (dry basis)?

5. MILLING AND GRADING OF RICE

Objectives: To be able to describe the equipment and process involved in rice milling and grading, to identify the three factors that cause losses in milling, and to describe the steps to prevent or reduce losses in milling.

Teaching aids: Figures 1 to 12

INTRODUCTION

Every farmer who has his paddy milled wants more whole grains and fewer brokens. A higher percentage of whole grains or a higher head rice yield means better quality and a higher price. Consequently there would be fewer broken grains which sell at a relatively lower price. The objective of a rice mill is to produce out of a pre-cleaned paddy milled rice suitable for human consumption — rice that is free of paddy grains, husk, weed seeds, and other foreign matter.

Like the farmer, the rice miller wants to reduce the breakage of rice grains during the milling process to secure maximum rice recovery and economic efficiency. Unfortunately the milling of rice is a complicated process and huge quantities of rice are lost because of improper handling of paddy before and during the milling operation. Rice farmers, dealers, and millers can prevent these losses to a large extent if they know where and how the losses occur. Therefore, this lesson describes the milling process, and points out where losses in milling can take place, and prescribes measures to prevent these losses.

PRESENTATION

A. *Definition of terms frequently used in rice processing*

Fig. 1 shows the rough composition of a paddy sample. The bulk grain contains varying amounts of *impurities* and about 14 percent *moisture*. The *husk* constitutes about 20 percent of the total weight. When the husk is removed, the germs are simultaneously recovered. What remains is *brown* rice. When brown rice is polished to remove the *bran*, *white rice* is obtained. White rice is composed of *small* and *large brokens*, and *head rice*.

B. *The milling process*

The process usually has four steps, precleaning, husk removal, separation, and whitening. Under special circumstances related to the marketing objectives, it will be necessary to separate the small and large brokens from the head rice for later mixing in accordance to market requirements. A fifth stage, grading, is therefore added to the above four stages.

1. *Precleaning* is a collective term covering all the equipment used to remove all the large and small impurities, including stones and metal, from the paddy.

It comprises dust aspirators (Fig. 2), oscillating self-cleaning sieves (Fig. 3), stone separators, and magnetic separators (Fig. 4).

2. *Husk removal*. The husk of the paddy grain is

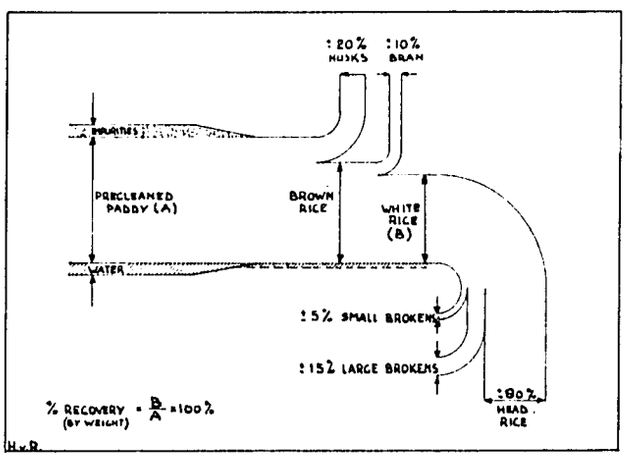


Fig. 1. Rice processing

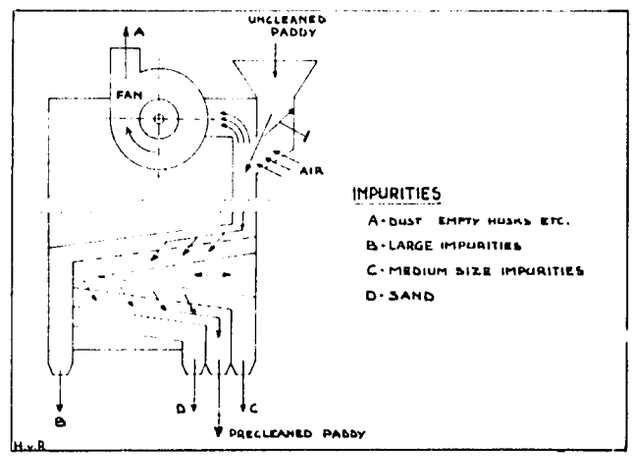


Fig. 2. Precleaning

removed under friction in basically two types of machine, namely: a) the under-runner-disc hullers (Fig. 5) consisting of two adjustable emery/silicium carbide-coated, horizontally-installed discs of which the bottom rotates and the top holds a fixed position; and b) the rubber roll type hullers (Fig. 6), consisting mainly of two adjustable rubber rolls, rotating at different speeds in opposite directions. One roll is adjustable to set the correct clearance.

3. *Separation.* In the separation section of the rice mill, between the hulling and the whitening sections, the following operations take place:

a) removal of dust through oscillating sieves and/or suction blowers
b) separation of small brokens prior to husk aspiration
c) separation of the husk through aspiration
d) separation of paddy from the brown rice in paddy separators.

The separated paddy — so-called return paddy — generally is smaller and is returned to the hulling section for husk removal in a smaller, specially adjusted huller (Fig. 7).

4. *Whitening* of rice concerns the process by which the bran layer and the germs of the brown rice are removed. Quite often this process is called "milling" or "polishing", causing some confusion in international contacts.

Whitening is carried out in cone-shaped vertical whitening machines (Fig. 8) or in cylindrical-type horizontal whitening machines. Both types of machines perform their operation under pressure, bringing the grain in contact with the abrasive surface of the emery/silicium carbide-coated whitening cones or rolls.

To reduce the breakage of the grains, multi-pass whitening through at least three machines is recommended (Fig. 9).

5. *Grading* of rice in rice mills covers the equipment for separating brokens from the head rice. Small brokens are separated through sifters and large brokens through rotating trieur cylinders (Fig. 10).

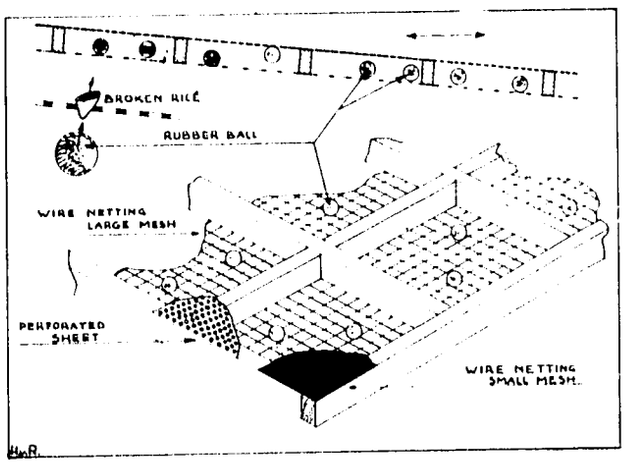


Fig. 3. Self cleaning sieve

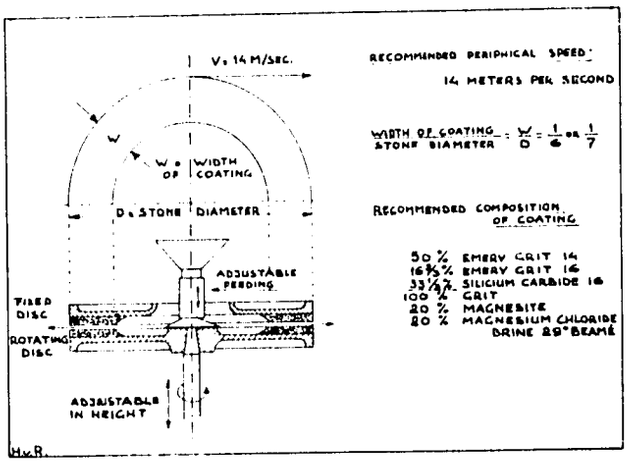


Fig. 5. Under-runner disc huller

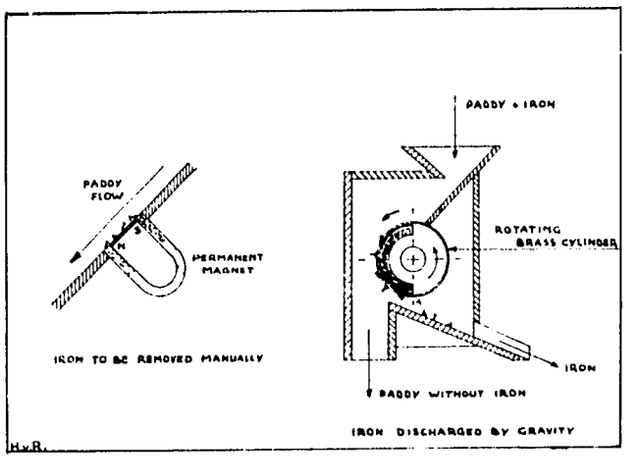


Fig. 4 Magnetic separators

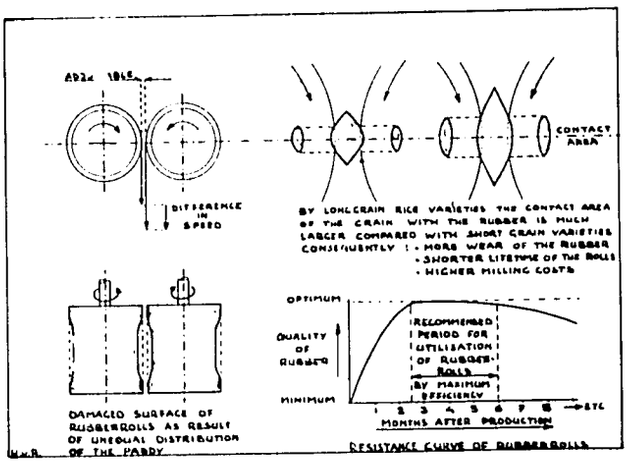


Fig. 6. Rubber roll huller

In the sifters small brokens separate from the large brokens and head rice because these grain particles have a smaller diameter than the large brokens and head rice grains. The trieur cylinders separate large brokens from head rice grains by the difference in length of the individual grains.

If desired the graded rice can be mixed through volumetric adjustable mixers (Fig. 11) to meet variable market requirements.

C. *Losses in milling*

Three factors cause losses in milling:

1. *Rice being broken.* As seen above, rice milling machines employ friction to remove the husk and bran layers. As long as a grain is not broken, the frictional operation will affect only the bran-layer-surface (Fig. 12). However, as soon as a rice grain is broken in two, three, or more pieces due to improper harvesting, drying or milling, the total grain area is exposed and the frictional operation is increased by the broken surfaces of the grains. During the whitening operation, a layer of the rice grain will be removed from the broken surfaces as rice flour and mixed with the bran. At the same time the sharp edges of the breakliners will be rounded. Consequently, more bran of lighter color will be produced and this will automatically reduce the recovery of white rice.

The higher the percentage of brokens, the lower the recovery in head rice.

2. *Rice damaged by insects, birds, mice, and rats.* When the paddy is still in the field or during storage, it is often exposed to birds, rats, and insects. Heavy damage of these pests may leave the paddy with only rice husks.

3. *Improper milling.* The third reason for losses is improperly constructed milling machines or improperly adjusted and maintained milling equipment. Incomplete or wrong arrangement of the milling machines in a rice mill may also cause increased grain breakage.

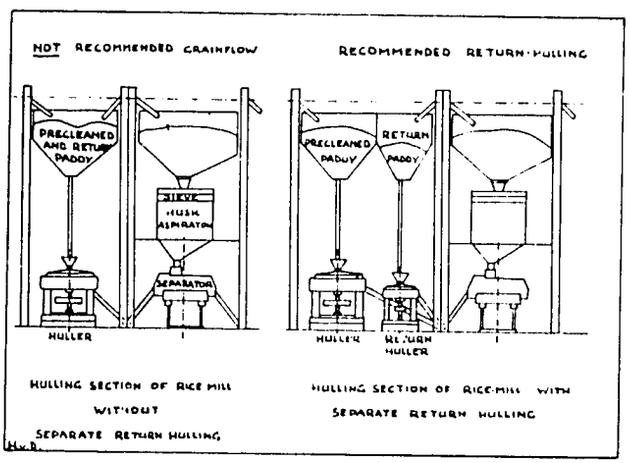


Fig. 7. Return hulling

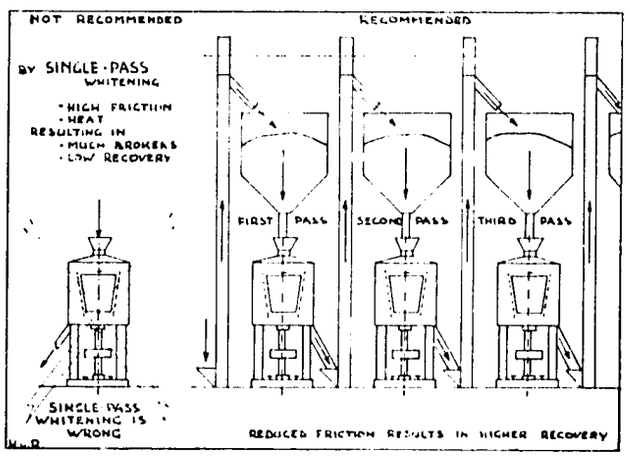


Fig. 9. Multipass whitening

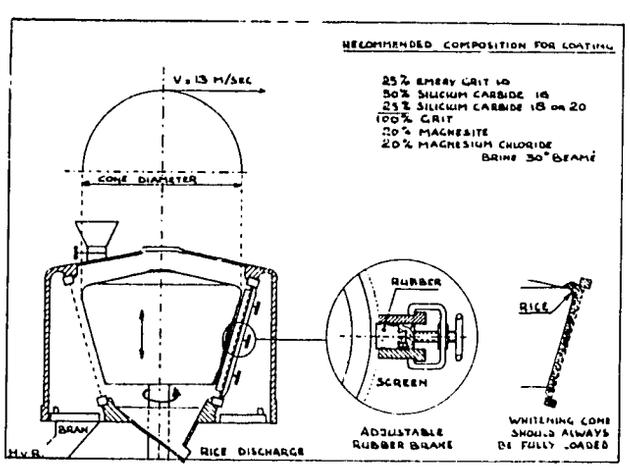


Fig. 8. Whitening cone

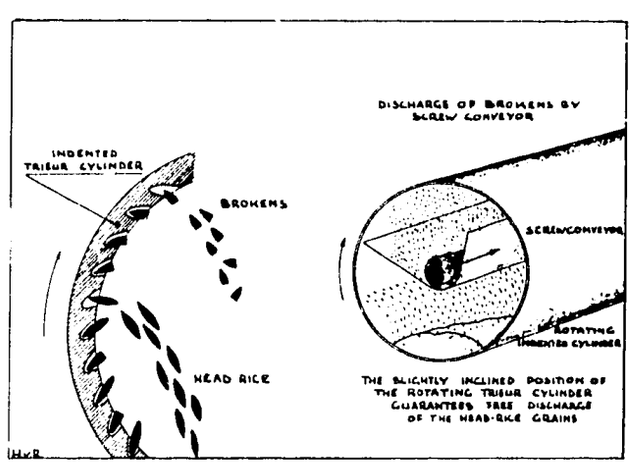


Fig. 10. Grading of rice by length

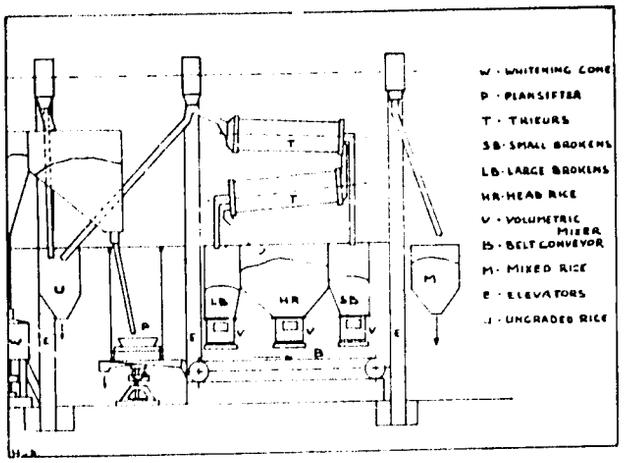


Fig. 11. Rice grading and mixing

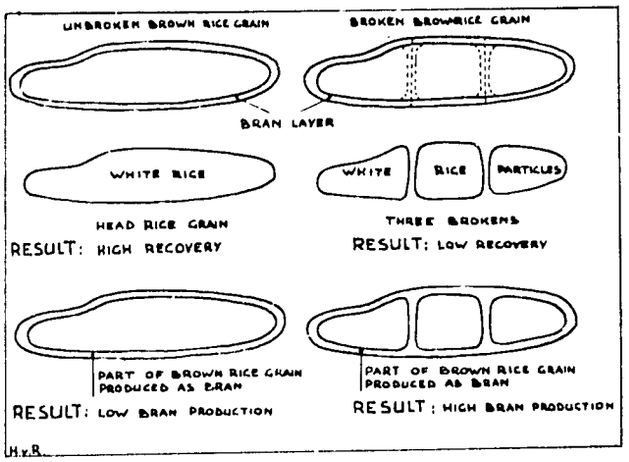


Fig. 12. Consequences of grain breakage.

D. *Preventing losses in milling*

Knowing the causes of losses in milling, the rice farmer or dealer may be able to obtain a higher percentage of head rice by practicing proper preventive measures. Although he may not have control over all the various milling machines, he can prevent cracking of paddy and insect, rat, and bird damage before he submits his paddy for milling.

Task 1. *Prevent cracking of paddy*

Read lesson on "Drying the harvested paddy," Tasks 1, 2, and 3.

Task 2. *Prevent insect, rat, and bird damage*

Read lesson on "Storing rice."

Task 3. *Dry paddy to optimum moisture content*

When paddy is too dry or too wet its milling recovery will be reduced because of the increase in the percentage of brokens. The moisture content of paddy which yields the highest head rice recovery, is between 13.5 and 14 percent. Therefore the farmer should see to it that his paddy is dried to this moisture content level before it is milled.

Task 4. *Operate milling equipment properly*

In a rice mill, the rice is most often broken in those machines whose function is based on friction. Friction at the same time causes heat. This increase in temperature of the grain, in combination with the friction, creates conditions favoring the breakage of the rice kernels.

Therefore the prevention of losses in the milling process is associated directly with friction and heat control.

Detailed discussion on this subject is outside the scope of this manual.

APPLICATION

Visit a rice mill. The instructor or the rice mill personnel will explain the operation of the mill. (This visit may be made on the same day as the visit to a rice drying plant.)

EVALUATION

1) Which machines in a rice mill are mainly responsible for the breakage of the grain? Why? What can be done to reduce the breakage of rice in these machines?
2) Describe a self-cleaning sieve or sifter; make a simple sketch of such a sieve and explain its importance in a rice mill.
3) Why should small brokens of brown rice be separated through a self-cleaning sieve before the aspiration of the husks in a ricemill?
4) When many grains are broken the rice mill recovery is low. Explain.
5) Explain the importance of multipass whitening.
6) Cite three factors that cause losses in milling.
7) Describe how to prevent losses in milling.

6. STORING RICE

Objectives: To be able to apply warehouse hygiene practices and pest control measures for bag and bulk storage under farmer's conditions.

Teaching aids: Figures 1, and 3
Slides showing a) deteriorated stored paddy and stored milled rice; b) stacking of bags of paddy; c) farmer's bulk storage areas

INTRODUCTION

Inadequate storage facilities and improper storage can cause considerable loss to rice farmers and dealers. Since harvested rice is a living biological organism, it continues to give off *carbon dioxide gas*, *water vapor*, and *heat*. The accumulation of these products of respiration promotes microbial activities, hence accelerating biological deterioration of the grain by mold and bacterial growth. Furthermore, insect pests of grain thrive best when the grain is improperly stored.

This lesson describes some important warehouse hygiene procedures to help farmers improve their storage practices.

PRESENTATION

Most farmers store only a certain amount of harvested rice for family consumption in sacks or in small bulk. Ideally, farmers should send the remaining newly harvested paddy to a warehouse using fully mechanized systems of integrated cleaning, drying, and storage. Such systems reduce the problems of poor cleaning, drying, and storage. If possible, rice should be stored as paddy instead of as milled rice, because paddy is relatively more resistant to insect damage and to grain moisture fluctuation than milled rice.

A. *Mechanical handling and storage system*

Newly harvested paddy is mechanically cleaned, conveyed automatically to the drier, and then to storage bins. This system seems to be the most logical approach to solving the problem of grain processing as rice production increases rapidly. But it requires a large capital outlay and highly trained personnel.

B. *Storage in sacks* is commonly practiced by many farmers, specially for stocks intended for seed. The seed are first dried, then placed in jute bags, and stacked in the barn. The farmer redries the seed occasionally, as weather permits, to keep his stock in good condition.

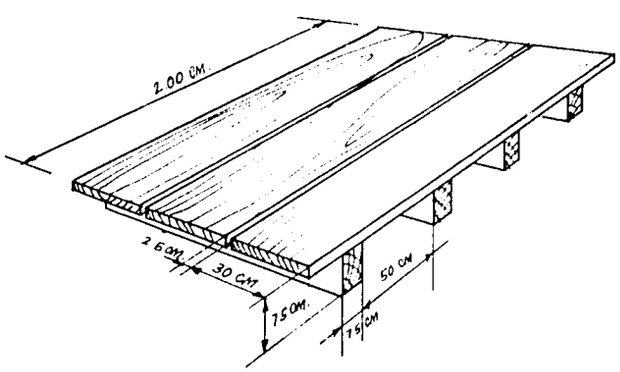


Fig. 1. Wooden pallet.

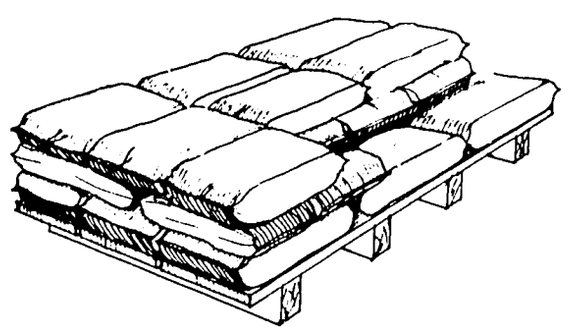


Fig. 2. Layers of bags stacked alternately.

How to store in sacks

Steps	Key points
1 Dry the paddy	a) Use any available means to dry the paddy. b) Final moisture content must be 13.5 percent M. C. Check moisture content frequently, see lesson on "Determining grain moisture." At this value, the grain is in equilibrium with atmospheric condition (78% relative humidity). STORING TOO DRY (LESS THAN 13.5% M. C.) OR TOO WET (MORE THAN 14% M. C.) PADDY CAUSES FREQUENT FLUCTUATION OF MOISTURE WITHIN THE GRAIN, HENCE MORE CRACKING. WET GRAINS ARE GOOD MEDIA FOR MOLD AND BACTERIAL GROWTH.
2 Pour paddy into bags	a) Use jute sacks or equivalent materials. Air-proof materials, like used and cleaned fertilizer containers, are *not* recommended unless frequently aerated to release the respiration by-products of the grain. b) *If the paddy is intended for seed*, soak sacks in 1 percent DDT and dry before filling them with seed. Bags impregnated with 0.25—0.5 percent chlordane or gamma BHC effectively prevent insect entry but may contaminate the contents. Thus, these insecticides should be used only on sacks that will contain rice to be used for seed. Label each bag indicating variety, date harvested, and seed source.
3 Clean the storage area	a) Remove all installations within the storage room b) Clean the area thoroughly. Give particular attention to cracks and crevices in floors and walls. c) Spray whole area with 2 percent malathion or lindane. Use protective mask while spraying. Cover old stock if there is any. Permit the spray to dry before bringing in new stock.
4 Install provisions for ventilation below and around the stack	a) Prepare as many of the wooden pallets shown in Fig. 1 as required. b) Place the pallets to form a platform. Leave a clear space of not less than 1 meter between pallets and walls. This prevents the accumulations of respiration products.
5 Stack the sacks	a) Cover wooden pallets with a large jute sheet. This prevents spilled stock from accumulating under the pallets. Also, the spilled stock can be recovered clean. b) Pile the sacks *only* on the jute sheet, within the pallet platform. c) Arrange the sacks in alternate directions between layers (see Fig. 2). d) When storing wet grain temporarily, do not pile more than three layers of sacks. Leave more space between sacks to facilitate ventilation. e) Never store agricultural chemicals, such as herbicides, insecticides, and fertilizers, near the rice stock.

6 Inspect the stock	a) Check the stock as frequently as possible (about twice a week) for signs of insect and rat infestation. b) Control heavy insect infestation by fumigating the whole stock with methyl bromide or phostoxin under gas-proof sheets. Then spray 1 percent malathion or lindane in the surrounding area of the fumigated stock. Bags impregnated with 0.25–0.5 percent chlordane or gamma BHC effectively prevent insect entry but may contaminate the contents. Thus, these insecticides should be used only on sacks that will contain rice to be used for seed. c) Check moisture content. Redry stock if its moisture content rises beyond 14 percent. This will keep seed fresh thus preventing grain cracking and maintaining high germination percentage. d) *For seed stock*, test seed germination if the period of germination exceeds 6 months.

C. *Bulk storage.* For many farmers, storing paddy in small bulk is a convenient way of keeping rice intended for home consumption. It eliminates expenditure for jute bags or the like and saves considerable storage space. Rice dealers and traders also find bulk storage the most economical method of preserving the quality of their commodity. Large scale bulk storage bins with mechanized ventilation and handling can be constructed for this purpose. Consult "Rice Production Manual, 1970 edition," pages 269 to 275, for details. For small-scale bulk storage, the procedure suggested below may prove useful:

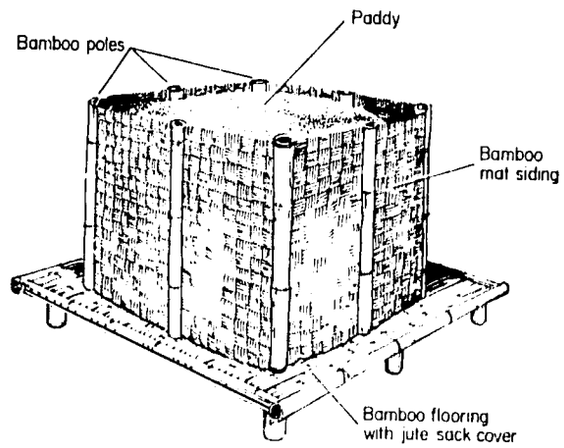


Fig. 3. Bulk storage using bamboo materials (not shown is a bamboo tray cover).

Steps	Key points
1 Dry the paddy	See above: Step 1 under B. "Storage in sacks."
2 Clean the storage area	See above: Step 3 under B. "Storage in sacks."
3 Prepare the flooring	a) Never store rice directly on the ground, cement or tiled floor, as these materials do not permit ventilation underneath the bulk. b) Use wooden pallets (Fig. 1) or an elevated bamboo or wire screen floor. c) Cover the floor with a large sheet of jute sack or similar materials to prevent spilled rice from accumulating under the floor and to enable clean recovery of spilled stocks.
4 Prepare the side walls	a) Use bamboo mat, or plywood, for sidings (Fig. 3). b) The whole enclosure should be rat-proof; the opening should be tightly closed with a large bamboo tray, or screen cover.
5 Pour the stock into the enclosure	a) Paddy should be at 13.5 to 14 percent moisture content. b) If fresh paddy has to be stocked in emergency cases, it should be dried as soon as possible.
6 Inspect the stock	See above: Step 2 under "Storage in sacks."

APPLICATION

Visit a rice warehouse, preferably on the same day you visit a rice mill. Point out the importance of ventilating the stored paddy. Show how stored paddy is dried periodically in bins.

EVALUATION

1) Why is harvested paddy considered a living biological product?
2) What causes biological deterioration of stored grain?
3) Why is it better to store paddy than milled rice?
4) What is mechanical handling and storage system?
5) Cite one advantage of bulk storage over sack storage.
6) List three reasons why stored seed should be inspected frequently.
7) Why should you not store grains which are too dry or too wet?
8) What would you do to control serious insect infestation in the stored paddy?
9) Why should every storage system be provided with ventilation?

7. SEED PURIFICATION

Objectives: To be able to maintain the purity of seed stocks by roguing or by selecting true-to-type plants.

Teaching aids: Slides showing a) field with off-types and weeds, and b) yield trial field with segregating plants

INTRODUCTION

Many farmers often say that a new rice variety runs out after several crop plantings! In fact no variety is *absolutely* pure. When released, it is pure only up to a certain degree. The apparent run-out of a variety or the presence of several off-type plants in the same field may be due to mixtures of other varieties around, or to seed stock being affected by virus or other diseases. Improper and careless handling may also alter the purity of the seed stock. When his seeds are not pure, the farmer will of course find it increasingly difficult to manage the field. Panicles will ripen at different times. Because mixed rice usually does not command a high price, farmers should take all steps necessary to maintain the purity of their stock. This lesson describes the causes of mixed seeds and the procedure for purifying seed.

PRESENTATION

A. *Causes of mixed seeds.* Farmers may get seeds mixed up in several ways:

1. Wrong label or identification
2. Dropped seeds in seedbeds or in fields. This causes volunteer plants.
3. Contaminated containers such as jute sacks.
4. Simultaneous threshing, drying, and storage of several varieties at one time.
5. Irrigation water carrying seeds of foreign varieties.
6. Natural cross pollination with other varieties (although this occurs less than 1 percent in rice).

B. *Procedures for purifying seeds*

1. *Roguing.* This is the easiest method that farmers can use on their seed field. The best criteria for roguing are heading date and height of the rice plant.

Step	Key points
1 Select a seed field	a) Set aside one or two plots in the field to produce seedstock for subsequent planting. b) The plot should be the best in the field in terms of soil fertility and access to a water source. c) Note the characteristics of the variety planted.
2 Observe off-type plants	a) Inspect the plants at maximum tillering stage or at heading stage. b) Walk slowly across the plot. Bend occasionally so that your eyes are at the same level as most of the panicles, or top of the plants. c) Look for taller or shorter plants and panicles, diseased or damaged plants, and weeds.
3 Remove the off-type plants	a) Pull out the off-type plants. b) Carry them out of the plot and destroy them. (e.g. feed to livestock buffalo, etc.)

2. *Mass selection* is a more difficult and time-consuming method. Use it when the seed has mixed with numerous off-type plants, and when roguing may lead to substantial loss of yield from the field.

Step	Key points
1 Characterize the variety to be selected (true-to-type plants)	a) Familiarize yourself with the desirable characters of the variety. b) Pay particular attention to plant height, erectness of leaves, tillering, panicle size, grain type, and heading date.
2 Select enough true-to-type plants	a) Do not collect from border rows. b) Collect as many true-to-type plants as needed.
3 Process the seed	a) Thresh, clean, and dry the seed carefully. Use only new containers. Label the container properly. b) Break seed dormancy if necessary.
4 Plant the selected seed	
5 Remove off-type plants in the succeeding generation	
6 Harvest the crop	Use the bulk of harvested seed as new seedstock.

3. *Progeny selection* is the most laborious method carried out only by experienced or competent workers. It is not recommended for farmers. Panicles of true-to-type plants are selected and planted to an individual row. Selection in the succeeding generation is made first on a row basis, and then among plants within selected rows. The seed from selected plants are then bulked to form new stock.

APPLICATION

Visit a seed field, preferably one that has many off-type plants. Point out the diseased and damaged plants, plants of different heights, and plants of different heading dates. Inspect a pedigree field or a yield trial field, if available. Point out the segregation within a new line or selection.

EVALUATION

1) Cite at least four causes of mixed seed.
2) What is the percentage of cross pollination in self-fertilized rice?
3) How does irrigation water cause mixed seed?
4) Why should seed be stored in new containers (sack)?
5) What is roguing?
6) When is the best time to rogue? Why?
7) What is mass selection?
8) Who should perform progeny selection? Why?