TRAINER'S MANUAL

RICE

HIS MAJESTY'S GOVERNMENT OF NEPAL

MINISTRY OF AGRICULTURE

DEPARTMENT OF AGRICULTURE

MANPOWER DEVELOPMENT AGRICULTURE PROJECT

KATHMANDU

JUNE 1987

TRAINER'S MANUAL [2]

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FOREWORD

There has been a great need for a trainer's manual in different disciplines of agriculture with particular reference to the country's situation to provide a guide in the teaching process. The most emphasis has been put on producing a comprehensive and up-to-date rice crop manual for use in agricultural training centres throughout the country. Trainers (S.M.S.) of the Regional Agriculture Training and Service Center, Khairenitar, with support from Manpower Development Agriculture Project, have produced this manual which, it is hoped, will be a help in teaching grassroot (JT/JTA) workers as well as leader farmers. I strongly feel that the trainers of RATSC would have immense creativity, if properly guided.

After the production of the training curricula by RATSC, Khairenitar, it was decided to produce a trainer's manual on different crops, beginning with rice crops and to be followed by others with the support of MDAP.

In the manual, there has been more of an emphasis on illustrations than on text in order to facilitate the instructor's understanding.

While developing this manual all available publications in this regard have been reviewed, and the advice of the Parwanipur Agriculture Station has been duly incorporated.

Keeping in view RATSC's curricula for the various groups of trainees, their duration of training, level of understanding and training needs, the trainer's manual has been tailored accordingly. The trainers would be in a position to pick up the needed units and parts according to the trainees' needs from the manual.

A prolonged discussion at RATSC for selecting the language for this manual resulted in the decision to use the English medium for the initial production as it would be used mostly by trained technicians of the Ministry of Agriculture. Translations into Nepali will be forthcoming.

I would like to commend Dr. P.L. Fedon (MDAP) for his concerted efforts and his active collaboration and advice to make this manual a success.

R.C. Gupta
Project Chief
RATSC Khairenitar

Trainers who actively participated in producing the Trainer's Manual in Rice are:

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INTRODUCTION

When the development of trainers' manuals was started in Shrawan 2043 (July 1986) "RICE" was selected as the topic for the first manual due to its importance as a major crop in Nepal and because of the availability of reference materials. In this context the INTERNATIONAL RICE RESEARCH INSTITUTE played a prominent role in providing information and illustrations without which this manual would not have materialized.

Being the first one of its kind in Nepal, this trainers' manual on rice should be regarded as a pioneer manual which may require improvement regarding various aspects.

A lot of effort has been invested by the different authors, not only to make the manual as comprehensive as possible but also to design it in such a way as to facilitate its utilization by trainers of agricultural faculties.

The manual serves two major purposes:

1. It provides the groundwork for training courses in terms of a detailed outline of subject matter contents.
2. It serves as a source of reference to enhance and refresh subject matter knowledge of trainers.

To facilitate its utilization for training courses, the contents of the manual is divided into units and subunits. Each unit can be taken as a separate teaching unit comprising one or more lessons. Thus, a systematic lesson plan which refers to specific training needs of training participants can be derived from the manual.

It is planned to enlarge the most important figures and tables and make them available as additional teaching aids.

Because of the unavailability of an up-to-date and comprehensive source of information regarding rice production under Nepali conditions, this trainers' manual is envisaged not only to become the backbone of agricultural training but also to stimulate discussion among respective subject matter specialists. Results of such a discussion will be considered for the first revised edition of this manual in due time.

Dr. Peter L. Fedon
Manpower Development
Agriculture Project

UNIT 1
ORIGIN OF RICE AND ITS DISTRIBUTION IN NEPAL

Early workers in rice have pointed out that rice originated in South-East Asia, India, China and Indo-China where different types of indigenous cultivars exist until now. Scientists indicated that the center of variation for the origin of rice was found in Nepal, Bhutan, Burma, Laos, Vietnam and the Yunnan province of China.

Today rice is grown in most of the Asian countries: India, Nepal, Pakistan, Indonesia, Thailand, Burma, Japan, the Philippines, South Vietnam, Campuchea, South Korea, Taiwan etc. and also in Spain, Australia, Italy and the U.S.A..

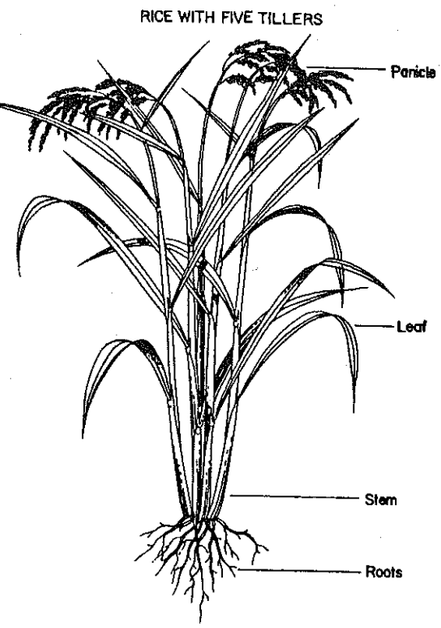
Rice is the most important staple food crop of Nepal. It is cultivated on 55% of the cultivated land and it is grown from the Terai belt (100 m) to an altitude of 3050 m within Nepal. Consumption of rice per person is 104 kg per year and about 2.45 million tons are produced per year. Distribution of rice area in Nepal is 2.11% in the mountains, 20.25% in the hills and 77.64% in the Terai. Details about area, production and yield rate of rice in Nepal are given by region in TABLE 1.

Year	1981/82	1982/83	1983/84	1984/85	1985/86
EASTERN REGION					
Area	428	388	429	444	436
Production	754	550	796	775	807
Yield	1.76	1.42	1.86	1.75	1.85
CENTRAL REGION					
Area	418	407	436	440	441
Production	961	573	1043	1002	1010
Yield	2.29	1.41	2.39	2.28	2.29
WESTERN REGION					
Area	248	248	250	271	280
Production	455	383	488	527	559
Yield	1.84	1.54	1.95	1.94	1.99
MID-WESTERN REGION					
Area	115	127	120	123	130
Production	224	187	243	226	244
Yield	1.9587	1.47	2.02	1.83	1.87
FAR WESTERN REGION					
Area	87	94	99	98	103
Production	166	139	188	179	184
Yield	1.90	1.48	1.89	1.82	1.79

TABLE 1: Area, production and yield rate of rice in Nepal by region (Area in '000 ha, production in '000 mt. and yield in t/ha).

UNIT 2
GENERAL DESCRIPTION OF RICE PLANT

U2.01 MORPHOLOGICAL DESCRIPTION



• A tiller is a shoot which includes the roots, stem, and leaves. It may or may not have a panicle.

FIGURE 1: Parts of rice plant

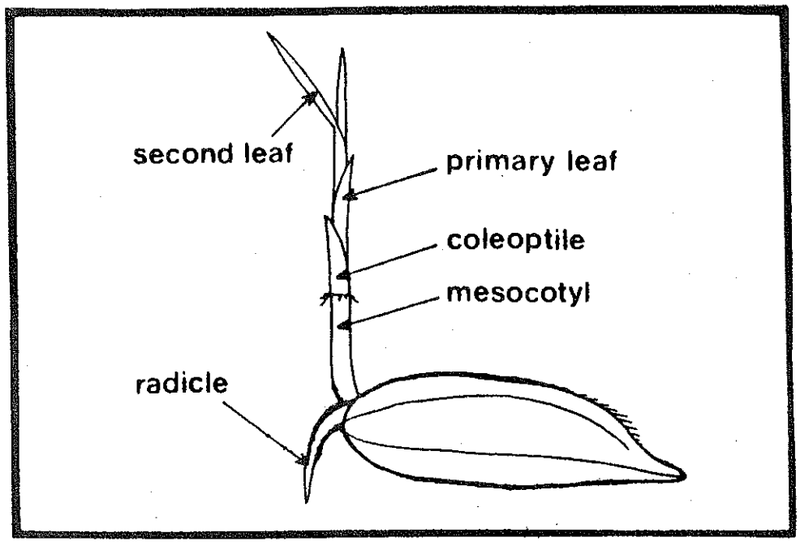


FIGURE 2: Germinating rice seed

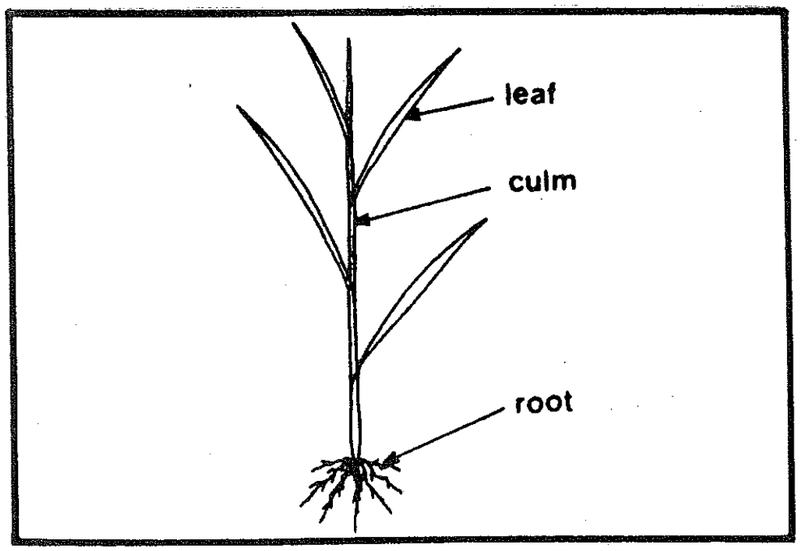


FIGURE 3: Vegetative parts of a tiller

Root

Root system of the rice plant:

Fibrous roots

Seminal roots
- primary (original) roots
- replaced by adventitious roots

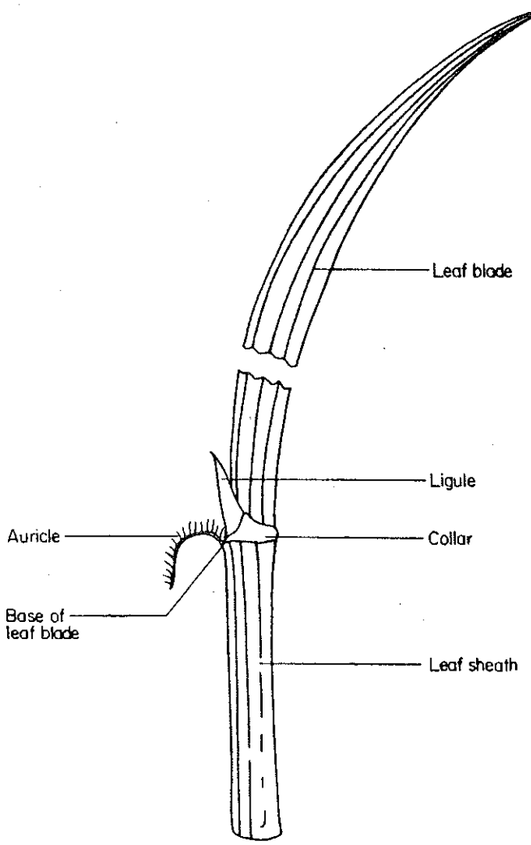
Adventitious roots
- secondary roots in lower nodes of culm
- freely branched

Stem

The stem or culm is made up of a series of nodes and internodes in alternate order. The nodes bear a leaf and the lower nodes a bud, which may grow into a tiller or shoot.

Leaves

The leaves are born at an angle at each node on the culm on opposite sides. For details of leaf see FIGURE 4 on next page.



- A rice leaf can be distinguished from other grasses by the presence of both the ligule and the auricle.
- A grass leaf has a collar but may have only a ligule or auricle or neither.
- A rice leaf, like the grasses, has parallel veins.

FIGURE 4: Parts of a leaf

Floral organs

The floral organs of rice consist of panicle and spikelets.

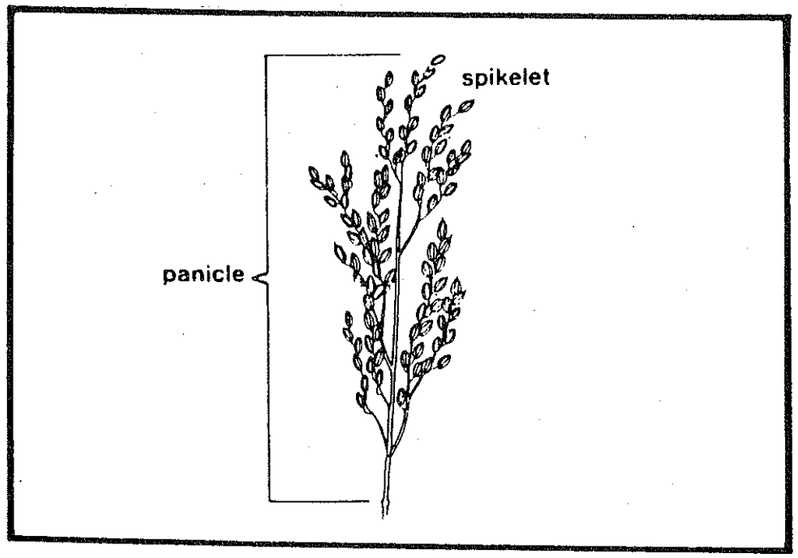


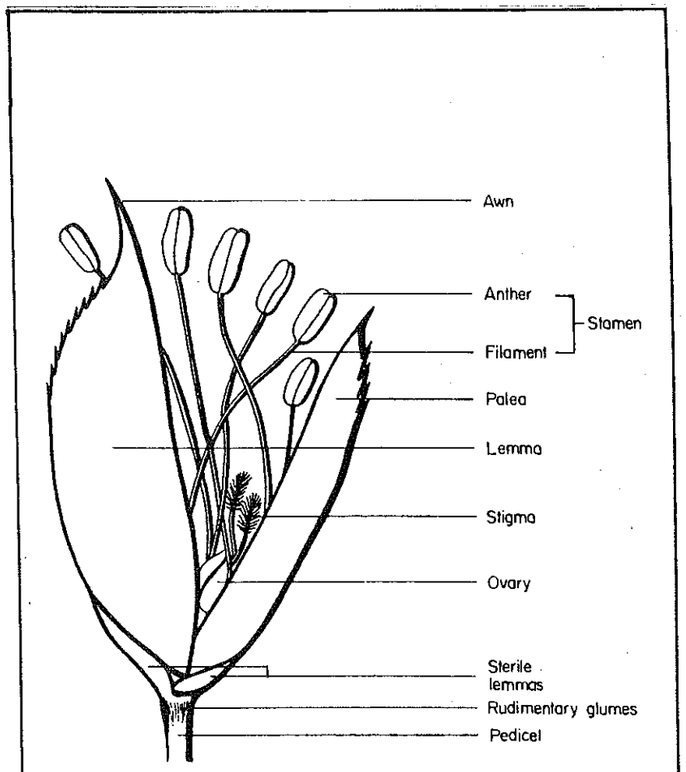
FIGURE 5: Floral organs (reproductive parts) of a mature tiller

Panicle

The panicle is a group of spikelets or grains borne on the uppermost node of the stem.

Spikelets

A spikelet is the unit of a panicle and consists of two sterile lemmas, the rachilla and the floret. The floret includes lemma, palea and the enclosed flower.

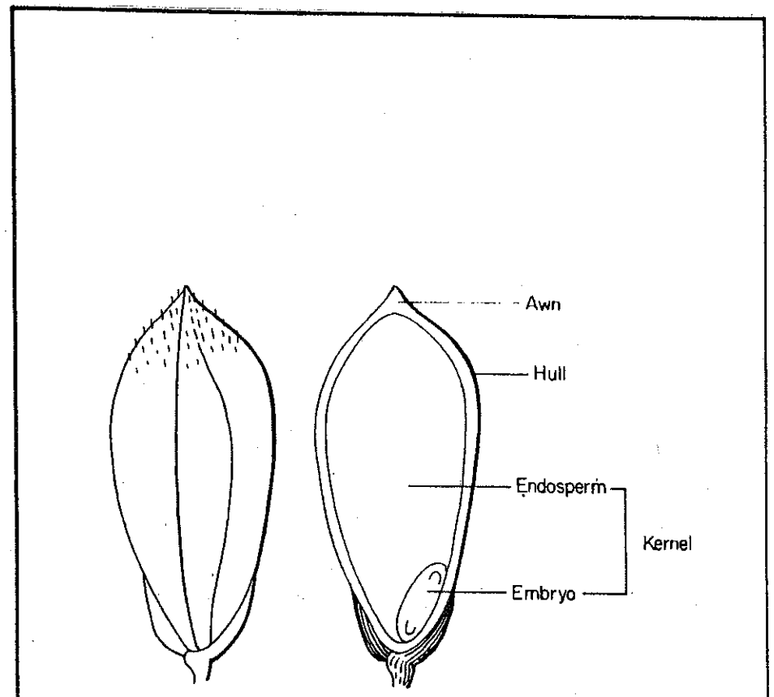


- Opening of the anthers occurs one day after the panicle comes out.
- Low temperature delays the opening of the anthers.
- Pollen from the anthers (like fine dust) have to reach the stigma and unite with the egg inside the ovary for the ovary to develop into a grain.

FIGURE 6: Parts of Spikelet

Grain

The grain is a ripened ovary, with lemma, palea, rachilla, sterile lemmas and the awn.



The seed was cut lengthwise

- The hull is the hard cover of the seed.
- The endosperm is made up mostly of starch, sugar, protein and fats. It is the storehouse of food for the embryo.
- Almost 80 percent of the endosperm is starch. The food needed for seed germination is in the endosperm.
- The embryo develops into the shoot and the roots.

FIGURE 7: Parts of a mature rice grain

U2.02 GROWTH PHASES OF RICE

3 growth phases of rice:
- vegetative phase
- reproductive phase
- ripening phase

The vegetative phase varies (35-65 days) according to the different varieties of rice, day length and climate.

The reproductive and ripening phase do not differ. It takes 35 days for the reproductive phase and 30 days for the ripening phase for most varieties.

For varieties with a longer vegetative phase, seedlings can be transplanted when they are up to 35 days old whereas the usual age of seedlings for transplanting is 25 days.

GROWTH PHASES	DURATION	GROWTH STAGES
VEGETATIVE PHASE	35-65 days	0: Germination to emergence
		1: Seedlings (5 leaves)
		2: Tillering
		3: Stem elongation
REPRODUCTIVE PHASE	35 days	4: Panicle initiation
		5: Heading
		6: Flowering
RIPENING	30 days	7: Milk grain
		8: Dough grain (yellowing)
		9: Mature grain

TABLE 2: Growth phases of rice

What is a tiller and how does it develop?

A tiller is a shoot which includes the roots, stem and leaves. It may or may not have a panicle. The panicle is developed from the panicle primordium (see Figure 8).

Auxillary primordia are present in the basal nodes from where tillers develop. If one primordium fails to develop another primordium will come out of the basal node and produce a panicle.

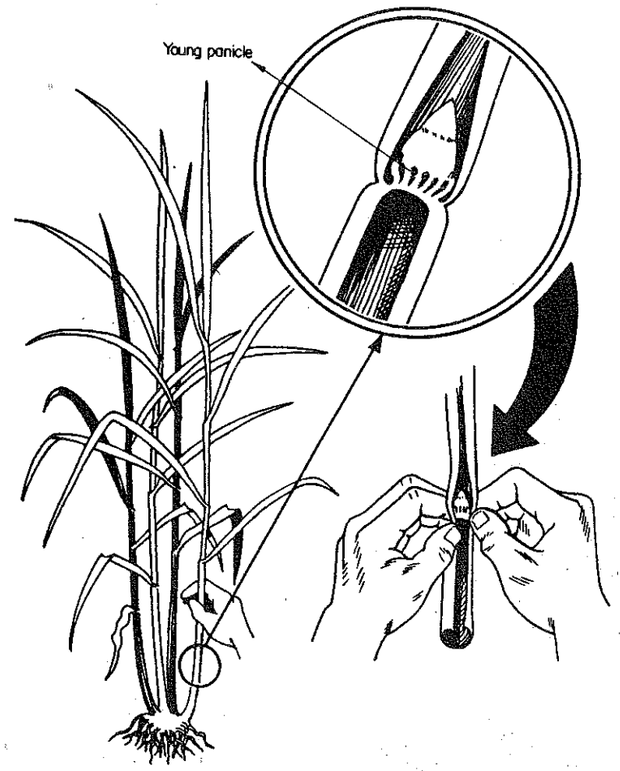


FIGURE 8: Panicle Primordium

- Primary (P) tillers come from the main stem.
- Secondary (S) tillers develop from the primary tillers and tertiary (T) tillers from the secondary tillers.
- The lower the point of origin on the main stem, the older is the tiller.

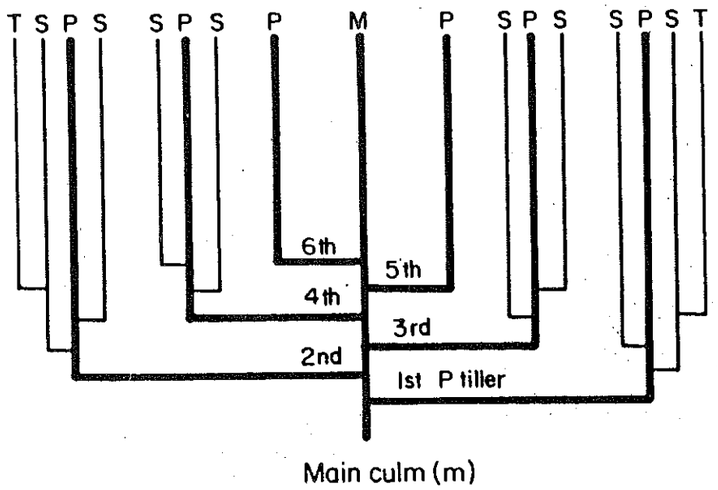


FIGURE 9: Tillering pattern

UNIT 3
CULTIVATION ASPECTS OF RICE

U3.01 CLIMATE

Climate includes a number of factors such as rainfall, solar radiation, day length, temperature, and wind. In Nepal, diversity in topography has a substantial influence on the climate conditions which effect the cultivation of rice (planting time, yield, pests and diseases).

Rice is grown primarily as a rainy season crop but it is also grown during summer in irrigated areas.

Rainfall

The onset of the monsoon, its duration, and the intensity of rain determine rice production. 85% of the rice is cultivated under rainfed conditions.

Solar radiation

The higher the solar radiation, the greater the yield of rice. To produce more rice high solar radiation in the last 30 days of the rice crop is most important. About 2000 hours of sunlight are needed for optimum rice production. Solar radiation is limited in the rainy season and is best during summer in Nepal.

Day length

The interval between sunrise and sunset is also called the "photoperiod". Rice is a short-day plant. All the varieties mature under a short photoperiod of about 10 hours. The day length is shorter in winter and longer in summer. But photoperiod non-sensitive varieties can also be planted in the summer season when the day length is more than 10 hours. The degree of sensitivity varies greatly between different varieties.

Temperature

The temperature required for rice production ranges from 20° - 37°C.

If the difference between day and night temperatures is more, then the grain yield of rice is higher. This is one of the physiological reasons for the grain yield being higher in the hills than in the Terai.

Wind

A gentle wind during the growing period of the rice plant is known to improve grain yields.

Climatic influence on panicle development

The number of panicles is affected most strongly by climatic conditions. High day temperatures and solar radiation and low night temperatures are apparently conducive to producing

more panicles without much reduction in spikelet numbers, thus increasing rice yield.

The relationship between grain yield and yield components is expressed as follows:

Grain yield = number panicles x number of spikelets per panicle x percentage of filled spikelets x weight of 1000 grains.

U3.02 TYPES OF RICE PLANTS AND VARIETAL CHARACTERISTICS

Races of rice	Eco-geographical distribution	Distinguishing plant features
Indica	Terai and mid-hills	Narrow to broad, light green leaves, profuse tillering and short to tall height.
Japanica	upper hills	Narrow dark green leaves, profuse tillering and short to intermediate height.
Javanica	Indonesia and neighbours	Broad, stiff, light green leaves, low tillering and tall.

TABLE 3: Three races of rice and their eco-geographic distribution

Recommended varieties

Recommended varieties of rice and their characteristics are given in TABLE 4, 5 and 6.

Varietal Name	Days to maturity	Plant height (cm)	Yield t/ha.
1. CH 45	110	120-130	2.8
2. Chandina	115	80	3.2
3. Laxmi	110-120	95	4.7
4. Parwanipur-1	120-125	86	3.0
5. IR-24	125	94	4.0
6. Bindeswari	130	100	3.5
7. Malika	120	119	4.0

TABLE 4: Varieties suitable for Terai and Inner Terai (Two crops annually possible)

Varietal Name	Days to maturity	Plant height (cm)	Yield t/ha.
1. Durga	128	91	4.5
2. Jaya	130	91	4.0
3. Janaki	130	99	3.5
4. IR-8	135	90	4.0
5. IR-22	145	90	2.8
6. Sabitri	135-140	95	3.0
7. IR-20	150	100	3.4
8. Masuli	165	140	4.3

TABLE 5: Varieties suitable for Terai and Inner Terai (one crop per year)

Varietal Name	Days to maturity	Plant height (cm)	Yield t/ha.
1. Taichung-176	125	90-115	4.0-6.0
2. Chainan-2	130	120	4.0-6.0
3. Tainan-1	130	90-110	4.0-6.0
4. Chainang-242	135	95-120	4.0-6.0
5. Himali	120-140	95-115	4.0-5.0
6. Kanchan	145	95-100	3.5-4.0

TABLE 6: Varieties suitable for hilly areas (one crop of rice per year)

Varietal Name	Days to maturity	Plant height (cm)	Yield t/ha.
1. CH-45	110-130	120	2.8
2. Khumal	105-120	100	4.0
3. Malika	120	119	4.0
4. Chandina	115	80	3.2

TABLE 7: Varieties suitable for lower hills and valleys (two crops of rice per year)

U3.03 SEED SELECTION AND TREATMENTS

Seed selection is a very important aspect of rice cultivation.

Why select good seeds?

1. For healthy seedlings having more roots.
2. Healthy seedlings will grow faster than the poor seedlings when transplanted in the field.
3. Good seeds result in uniform germination and growth.

Characteristics of good seeds

1. Varietal purity - The plants resulting from the seeds must possess characteristics of the variety to which the seeds belong.
2. Germination - 85% or more of the seeds must germinate.
3. Uniformity in size - Seeds of equal size have uniform germination and seedling vigor.
4. Free from mixture - The seeds should be free from mixture with other varieties, weed seeds and other materials.
5. Free from seed-borne disease - Good seeds are obtained from disease free plants and seeds should be free from seed-borne diseases.
6. Mechanical purity - Pure seeds should be free from mechanical injury.

Seed treatment against diseases

1. Dry seed treatment is done against fungal disease by Bavistin WP or Thiride or Ceresan or Dithane M-45 @ 2-2.5 g/kg seed during sowing or 5-7 days before sowing.
2. Streptocycline or Agrimycin 100 @ 1 g/10 litres of water is used against bacterial diseases and seed treatment is done for 6-8 hours after salt water treatment.

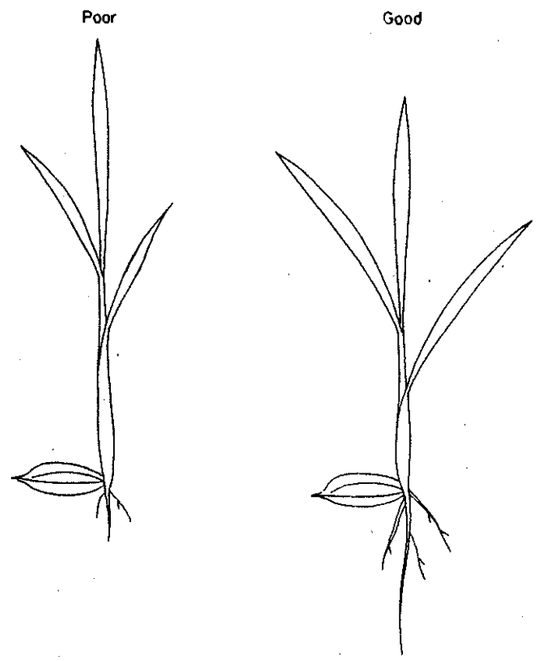


FIGURE 10: Healthy and poor seedlings

3. Salt water treatment: 1.65 kg of common salt or 2.20 kg of ammonium sulfate is used mixed in 10 litres of clean water. This solution is ready to treat 1 kg of rice seed.
   - seeds are thoroughly stirred in the solution and allowed to settle.
   - floating seeds are removed.
   - good seeds are washed in fresh water and then dried.

Germination test

A germination test is another essential step in seed testing.
- it helps to calculate the amount of seeds required to plant a field.
- a germination test is conducted 1-2 weeks before sowing.

Methods of conducting a germination test

a) Ragdoll method:

Take 400 seeds from a mixture of composite samples at random. Distribute 100 seeds evenly in rows on a piece of wet muslin cloth (30 cm x 25 cm). Roll the cloth around a stick for support and tie at both ends. Keep them in a warm place in a moist condition throughout. Count the germinated seeds on the 4th and 8th day for germination percentage.

b) Banana bract method:

Four hundred seeds are used for this method. The inner layer of a banana bract is removed and the seeds kept in the small holes. Regular moistening of the seeds is necessary. Germination counting is done on the 4th and 8th day.

How to calculate the germination percentage?

$$\text{Germination (\%)} = \frac{\text{No. of seeds germinated x 100}}{\text{No. of seeds put for germination}}$$

IF GERMINATION IS LOWER THAN 85% BUT ABOVE 60% THE AMOUNT OF SEED NEEDED FOR ONE ROPANI MUST BE CALCULATED.

Description	Foundation seed	Certified seed Grade-I	Certified seed Grade-II
1. Pure seeds (Minimum)	99 %	97 %	97 %
2. Mixed seeds per 100 g	2	6	5
3. Weed seeds per 100 g	6	15	15
4. Other ingredients	2 %	2 %	2 %
5. Germination	85 %	85 %	85 %
6. Moisture content	13 %	13 %	13 %

TABLE 8: Seed certification standards

How many kg of seed are needed for one ropani?

Suppose the seed rate of rice is 2.5 kg/ropani and the germination percentage of seed is 75 %, then the quantity of seeds needed will be 2.5 multiplied by 100 and divided by 75.

$$\frac{2.5 \times 100}{75} = 3.333 \text{ kg}$$

Therefore, 3.333 kg of seed should be sown in the nursery bed for transplantation to a ropani of land.

U3.04 UPLAND RICE PLANTING

About 9% of the rice areas in Nepal fall under upland rice. It is grown in rotation with finger-millet, tori or sarson and wheat.

Upland rice (Ghaiya) is solely dependant upon rain water availability.

Features of upland rice culture:

1. Grown in areas where no irrigation facilities exist.

2. No bund or levees are required.

3. The success of upland rice depends on a favourable monsoon.

4. It is harvested in August - September (Mid-Shrawan to mid-Aswin) and consumed locally.

5. Contour farming of rice in areas of assured rainfall over 3-4 months is used.

6. It requires a more fertile soil than irrigated paddy.

7. Land preparation depends upon the soil type and its moisture content. Two ploughings, each followed by planking is usually sufficient to prepare the land. Then, sowing is done by uniform broadcasting of seeds at the rate of 70 kg per ha. Light planking is done immediately after broadcasting of seeds so as to cover with soil.

8. April (Mid-Chaitra to Mid-Baisak) is the appropriate sowing time.

9. All nutrients are given as a basal application.

10. Weeding is done 4 weeks after sowing May-June (Jestha) and gap-filling is done by transplanting seedlings during weeding. Weeding depends on the weed flora.

11. Insect pests, diseases and their control measures are similar to that of wetland rice (paddy).

U3.05 THREE DIFFERENT METHODS OF RAISING SEEDLINGS FOR LOWLAND RICE

Reasons for nursery management

1. To assure intensive care of seedlings in a small nursery area.

2. Less quantity of seed is required.

3. To ensure uniform plant population in the field after transplanting.

4. To facilitate timely transplanting and quick stand establishment of the crop.

5. To facilitate more efficient weed control and intercultural operations of the transplanted rice.

CRITERIA	WETBED	DRYBED	DAPOG
Seed rate (kg/ha)	45- 50	45- 50	45-65
Seed bed area (m^2/ha)	400-500	400-500	15-25
Soaking time (hrs)	24	24*	24
Incubation time (hrs)	36- 48	24*	48
Soaking to transplanting (days)	20- 25	20- 30	9-14
Transplanting depth (cm)	1.5-3.0	1.5-3.0	1.5
Seedlings/hill	2-3	2-3	5-10

*Not recommended if soil is dry

TABLE 9: Three different methods of raising seedlings

METHODS	ADVANTAGES	DISADVANTAGES
a. Wetbed	Growth is quick with strong and sturdy seedlings.	Needs continuous irrigation.
	Suitable in most soil types.	Uprooting of seedlings is difficult.
	Land preparation is early.	
b. Dry bed	Better results of the seedlings than both other methods.	Land preparation is costly.
	Better results with limited water supply.	Sandy and stiff clay soil not useful.
	Uprooting is easier.	
	Seedlings can resist adverse conditions.	
c. Dapog	Requires less seed bed area.	Useful only in Terai.
	Seedlings are ready for transplanting in fewer days.	Requires more seeds. Needs better management and assured irrigation.
	Seedlings recover faster after transplanting.	Seedlings are harder to transplant.
	Less expensive.	Seedlings are less competitive against weeds.
	No cost of (uprooting) seedlings.	Requires partial shade condition.

TABLE 10: Advantages and disadvantages of different nursery management methods.

U3.06 PREPARATION OF A WET OR DRY SEEDBED

Steps:

1. Select best location having no shading effect.

2. Calculate the area required:
   The area required for one ha. planting ranges from 400-500 sq.m.. Each seed-bed should be about 1-1.5 m wide and the length depends on how much seedbed area is needed. Usually one seedbed is not bigger than 25 sq.m. and one such bed is enough for one ropani of land.

Use string or twine with four bamboo stakes to outline the predetermined area with the use of tapes or other measuring devices.

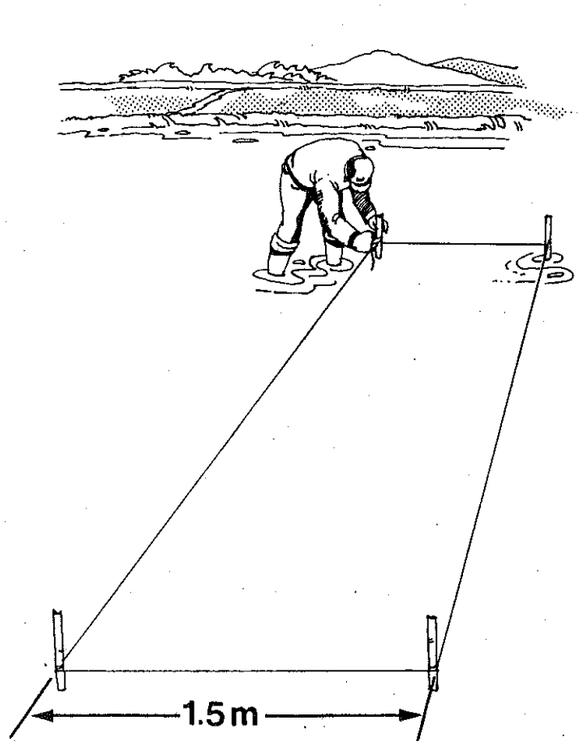


FIGURE 11: Specification for wet or dry seedbed

3. Prepare land for seedbed:
   The seedbed should be prepared 30-35 days before the planting time in March-April (Mid-Phagun to mid-Baisak) after the first summer shower. Harrowing 2-3 times with 7-10 days interval between operations is sufficient to prepare the field and 200 kg compost per 25 sq.m. is applied in the beginning.

4. Flood the field in between operations for wetbed method.

5. Raise the seedbed 4-5 cm above the ground to facilitate drainage.

6. During final land preparation or final puddling and levelling, incorporate either 100 g of ammonium sulfate or 40 g of urea/sq.m. area if no compost is applied initially during land preparation.

7. After soaking the seeds for 24 hours the seeds are incubated in a warm, shady place for 36-48 hours. The seeds are never allowed to dry up, so occasional moistening of the seeds is needed. Soaking and moistening the seeds hastens germination.

8. Sow the pre-germinated seeds evenly on the entire area. The mud on the top of the seed bed should have settled overnight so as to avoid sinkage of the seed.
   But for a dry seed bed, sow either pre-soaked or dry seed evenly and cover with soil thinly.
   In both cases, about 100 g seed per sq.m. should be sown.

9. Irrigation and drainage should be properly maintained.

Care of the nursery bed

1. Irrigate the seedbed:

   Wetbed - After 4 days maintain water 2-3 cm deep and gradually increase the water depth to 5 cm to control weeds.

   Drybed - Irrigate the seedbed after germination and don't allow the soil to dry.

2. Protect the seedlings:
   - pull out the weeds manually.
   - spray the seedling with 0.1% of Metacid 7 days after sowing and if required repeat the spraying after one week.
   - also, seedbeds should be well protected from rats, birds and animals.

3. If deficiency symptoms are visible top-dressing of nitrogen is done in wetbed and drybed methods. Either 50-100 g of ammonium sulfate or 20-40 g urea per sq.m. of seedbed is broadcasted 10 days after sowing. Yellowing of the lower leaves indicates that the seedlings need nitrogen.

4. In the case of zinc problem areas, one of the following measures should be taken.
   - Soil treatment with zinc sulfate at the rate of 100 kg/ha.
     or,
   - Coat the pre-germinated seeds with zinc oxide paste 2 g/100 g of seeds,
     or,
   - Dipping of seedlings in 1-2 % solution of zinc oxide.

U3.07 RAISING SEEDLINGS BY THE DAPOG METHOD

Raising Seedlings by the Dapog Method

... is a very new method suitable for the Terai and Inner-Terai of Nepal.

... is explained on the following pages.

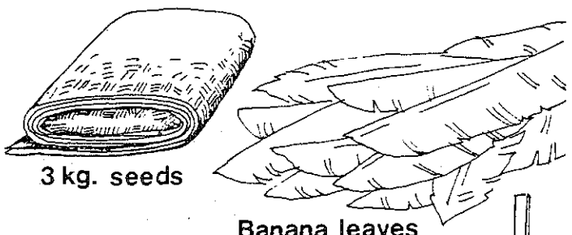
... - its advantages and disadvantages are shown on page 25.

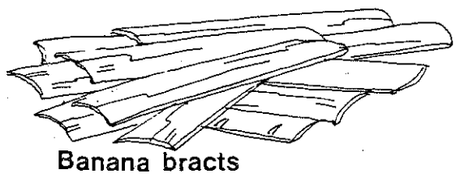
OPERATION 1
PREPARING THE DAPOG SEEDBED

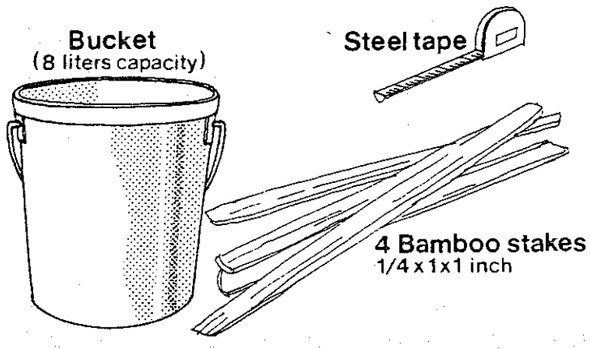
Steps

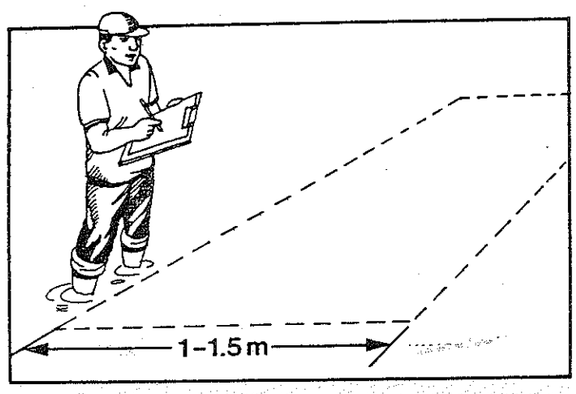
1. *Compute the area required.*

Use 1 sq.m. seedbed for every 3 kg. seeds. The dapog method requires 15-25m² seedbed per hectare. The width must be 1-1.5 m. for easy management.



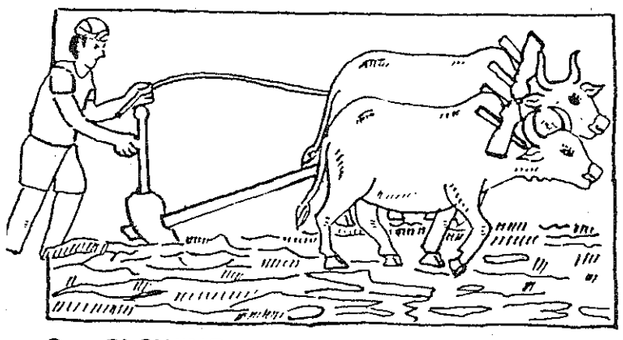




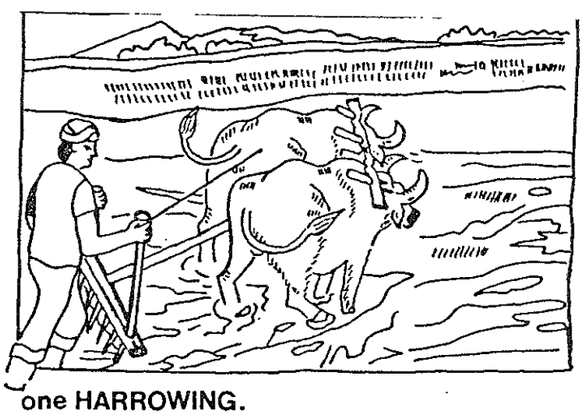


2. *Prepare the land.*

Usually one plowing followed by one harrowing is sufficient to prepare the land.



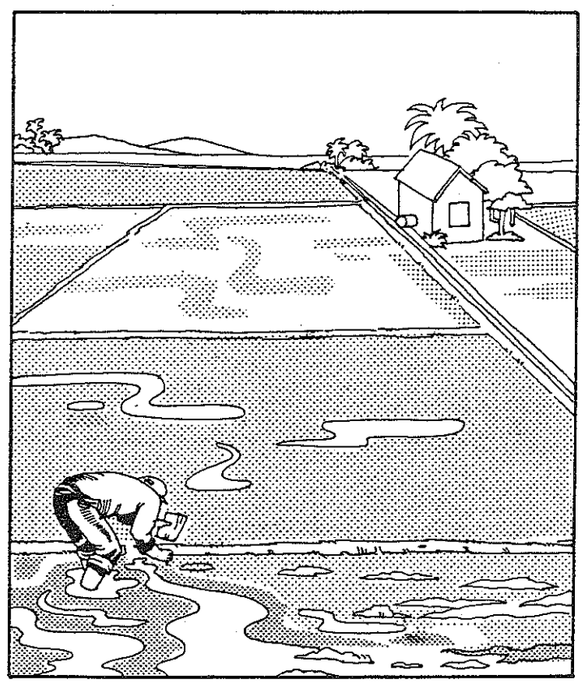
One PLOWING...



one HARROWING.

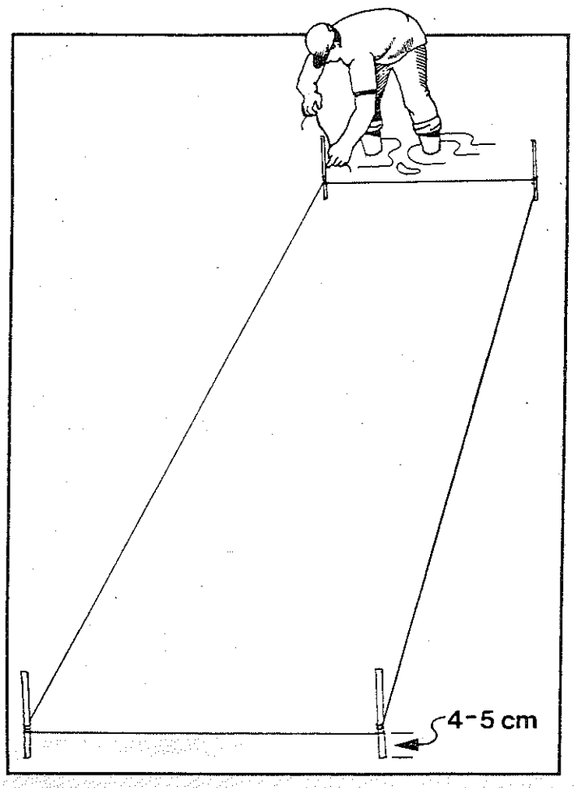
3. *Flood the field.*

Maintain enough water to cover the soil surface. This serves as a guide in levelling the soil.



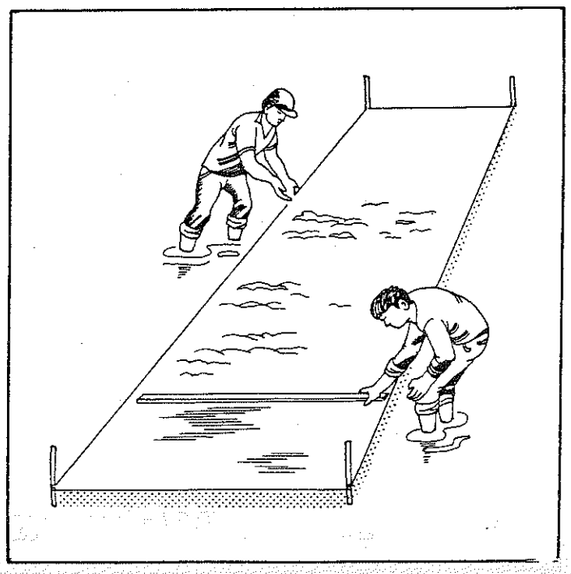
4. *Measure the area.*

Use string or abaca twine and bamboo stakes to outline the predetermined area with the help of steel tape or other measuring devices.



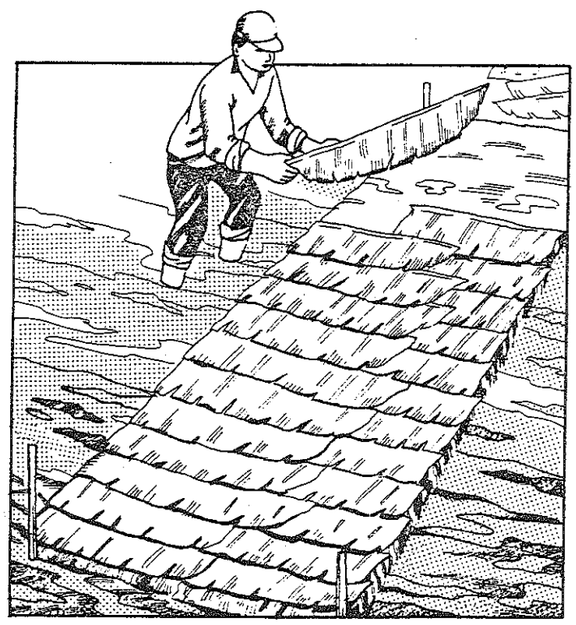
5. *Construct the seedbed.*

Collect mud around and outside the area outlined and transfer it to the enclosed area. The height of the seedbed should be increased to 4 to 5 cm above the original soil level. Smooth and level the surface of the seedbed.



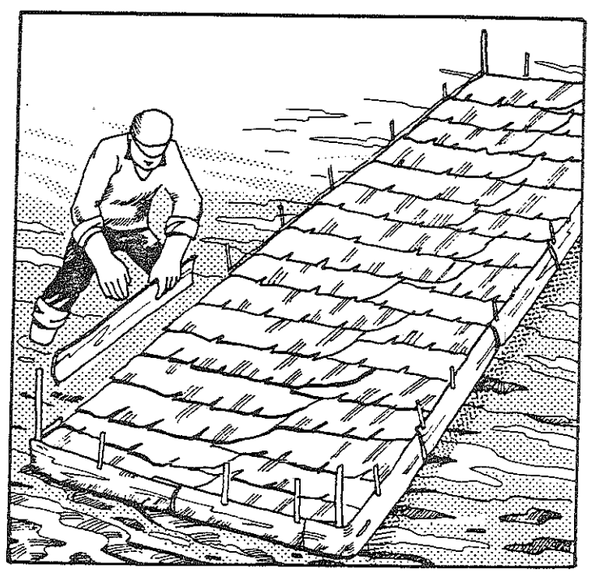
6. *Cover the surface of the seedbed.*

Allow 1 day for the mud to settle before covering the bed. Use banana leaves with the midribs removed, or plastic sheets spread on top of the seedbed. Leaves should be spread with the underside up. The leaves should overlap each other with no holes or breakage.



7. *Surround the seedbed with banana bracts.*

Lay strips of 2-inch wide banana bracts carefully along the periphery of the seedbed. Secure the bracts into the soil with thin bamboo pegs to keep the bracts upright and firmly in place.



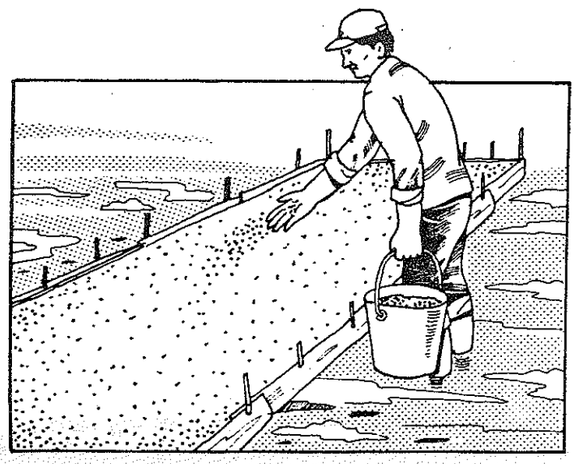
OPERATION 2

SOWING SEEDS IN THE DAPOG SEEDBED

Steps

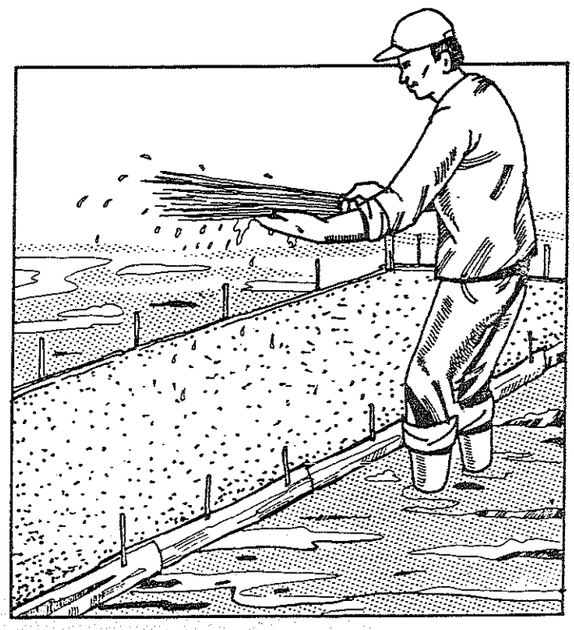
1. *Broadcast the seeds.*

Broadcast the pregerminated seeds over the banana leaf enclosure. Pack the seeds to make a uniform layer of three seeds thick. Do not press heavily, or the flatness of the seedbed will be destroyed.



2. *Water the seeds.*

Sprinkle water into the seed using a broomstick or a gardener's sprinkler. Do not pour water or you will displace the seeds.



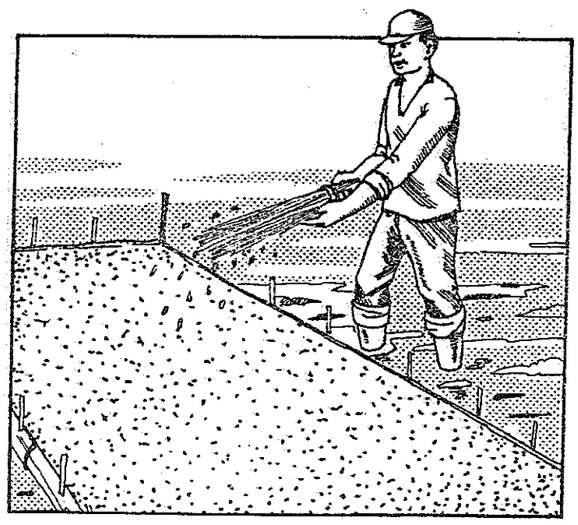
OPERATION 3

CARE OF DAPOG SEEDBED

Steps

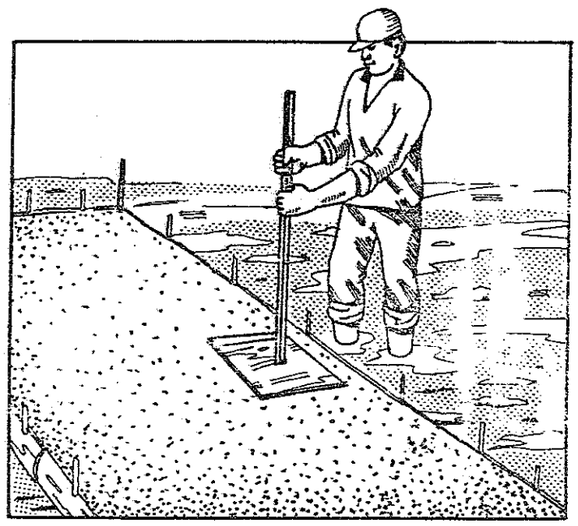
1. *Water the seedbed.*

Water the seedbed 3-4 times a day with a gardener's sprinkler or a broomstick. After 4 days, irrigate the seedbed continuously to a depth of 1-2 cm of water. Drain it during night time.



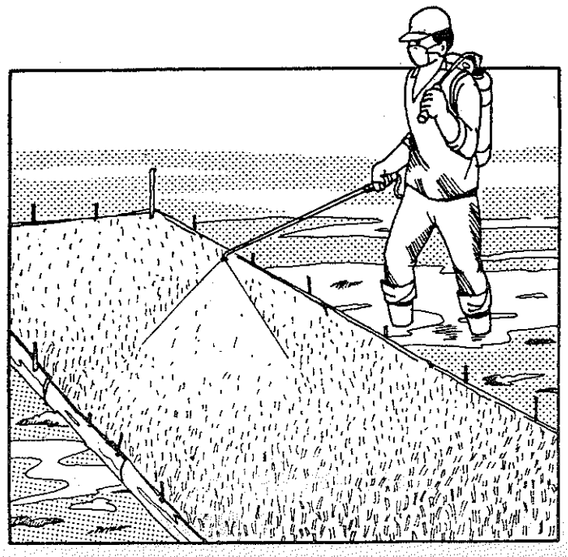
2. *Press the seeds gently on a daily interval.*

Press the seeds lightly by hand or with a woodboard once a day until the fourth day. This maintains even germination and keeps the roots of the seedlings in contact with the banana leaves or plastic sheet.

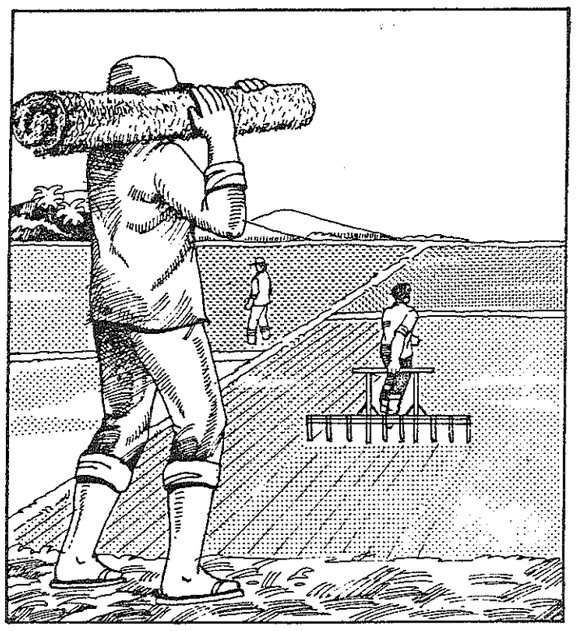


3. *Protect seedlings from pests.*

On the fifth and tenth day, spray recommended insecticide on the seedbed and around all sides of the bed. If necessary, protect the seedbed against rats, birds and animals.



2. *Bring roll of seedlings to the field to be planted.*



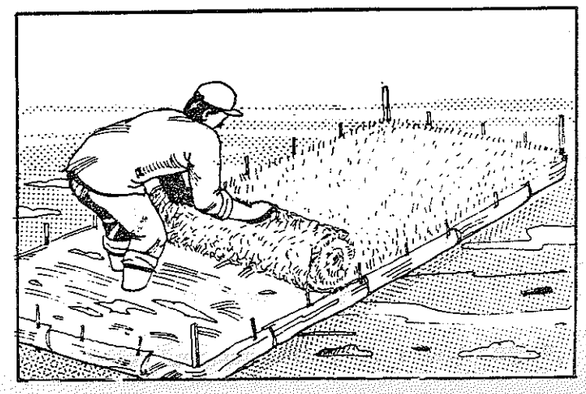
OPERATION 4

PREPARING SEEDLINGS FOR TRANSPLANTING

Steps

1. *Roll the seedlings.*

Loosen and roll the seedling into a convenient bundle. Seedlings are ready for transplanting 9-14 days after sowing. Roll the dapog, making the leaves turn inward and roots outward.



Support Information

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:

   $$\frac{20}{2} = 6.66 \text{ sq m}$$

2. What are the characteristics of good rice seedlings from a dapog seedbed?

   Characteristics of good rice seedling from a dapog seedbed

   a. They are of uniform size

   b. They are free from diseases, pest damage and mechanical injury

   c. They are hardy, having short but erect leaves and vigorous roots

3. What are the advantages and disadvantages of the dapog method?

Advantages:

a. time in the seedbed is greatly reduced

b. area required for the seedbed is reduced

c. more choices for seedbed location

d. seedlings do not suffer from root or stem injury

e. pulling of seedlings is eliminated.

Disadvantages:

a. larger quantity of seeds are required

b. seedling are short

c. number of seedlings per hill cannot be controlled easily

4. When is the dapog method preferable?

The dapog is preferable in areas where water management is excellent.

5. How are banana leaves used in making the flooring of a dapog?

The midrib of the banana leaves should be removed and placed on top of the dapog seedbed.

6. Why should the seeds be pressed with a wooden board during the first four days?

The seeds should be pressed for the first four days so that the roots of the seedlings will be kept in contact with banana leaves to produce a uniform growth.

7. What care should be taken when watering the dapog seedbed?

The dapog seedbed should be watered with a sprinkler or broomstick so that the seeds will not be displaced.

8. When is the dapog seedling ready for transplanting? Why should you not wait for 20 days?

The seedling is ready 9-14 days after sowing. It should not be prolonged after this period because the seedling will start to deteriorate. The food stored in the endosperm will be exhausted.

9. Explain the versatility of dapog seedbed.

The dapog seedbed can be made in a variety of choices. A cement floor, a raft made of banana stalks with soils on top or an elevated platform can be used as seedbed.

U3.08 LAND PREPARATION FOR LOWLAND RICE

Land preparation is done in order to provide a favourable soil environment for the germination and growth of the crop.

Reasons for land preparation

1. To control weeds.
2. To incorporate organic materials in the soil.
3. To incorporate fertilizer and pesticides.
4. To turn soil into a "soft puddle" to ease transplanting.
5. To form a hard layer (plow sole) which reduces water loss during subsequent flooding.
6. To level the field for uniform distribution of irrigation water, fertilizer and pesticides.

Why land preparation should be started at least 2 to 3 weeks before transplanting:

1. To save seedlings from the effects of a high concentration of harmful substances generated by decomposing organic matter.
2. To allow the plants to utilize nutrients released during decomposition of organic matter.

Three phases of wetland tillage

1. Land soaking, in which water is absorbed until the soil is saturated.
2. Plowing with initial breaking and turning over of the soil.
3. Harrowing, during which big clods of soil are broken and puddled with water.

How many ploughings?

Usually, one ploughing and three puddlings a week are sufficient to get the land ready for transplanting. The farmer should always keep the field flooded from the first ploughing until planting time. Therefore, bunds should be well maintained.

Advantages of puddling

1. Improves weed control.
2. Eases transplanting.
3. Improves soil fertility and fertilizer management due to a reduced soil condition.
4. Reduces loss of water due to hard soil layer formation.

When to apply manures and fertilizers?

Apply compost or FYM during the first ploughing.

Apply all N, P and K fertilizers as a basal dose during the final land preparation in uplands.

Apply half a dose of nitrogen and a full dose of phosphatic and potash fertilizers after final puddling and levelling in the lowlands.

Top-dress the remaining half dose of N 35 days after transplanting.

U3.09 TRANSPLANTING

Transplanting is done only when the land has been well puddled, levelled, properly fertilized and excess water drained off (water not more than 1 cm deep).

Advantages of transplanting

1. Weeding is faster and more efficient.

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

3. Other field management operations, such as spraying, weeding and top dressing are made easier.

Disadvantage of transplanting

1. Labour cost is high.

2. Seedlings are exposed to possible injury during handling.

3. Plants tend to grow more slowly than when grown directly in the seedbed because of the recovery time needed after transplanting.

4. Harvesting is delayed by 7-10 days.

Uprooting of seedlings

1. Pull out 3-4 seedlings at a time with care.

2. During uprooting, a 5-6 cm water level is maintained.

3. Uprooting of seedlings should be done in the morning and transplanting should be preferably done during the same day.

4. Wash off the soil from the uprooted seedlings carefully and make bundles of a convenient size of 5-6 cm in diameter.

5. Keep seedling bundles in water and/or shade until they are used.

At what time should seedlings be transplanted?

When seedlings are at the 4-5 leaf stage or 21-25 days old (or 30-35 days for longer duration varieties). Usually seedlings of 20-25 cm height are ready for transplanting.

Method of transplanting in puddled field

1. Put 2-3 seedlings/hill in a straight line.

2. Transplant at 2-3 cm depth.

3. Transplant seedlings in a slanting position.

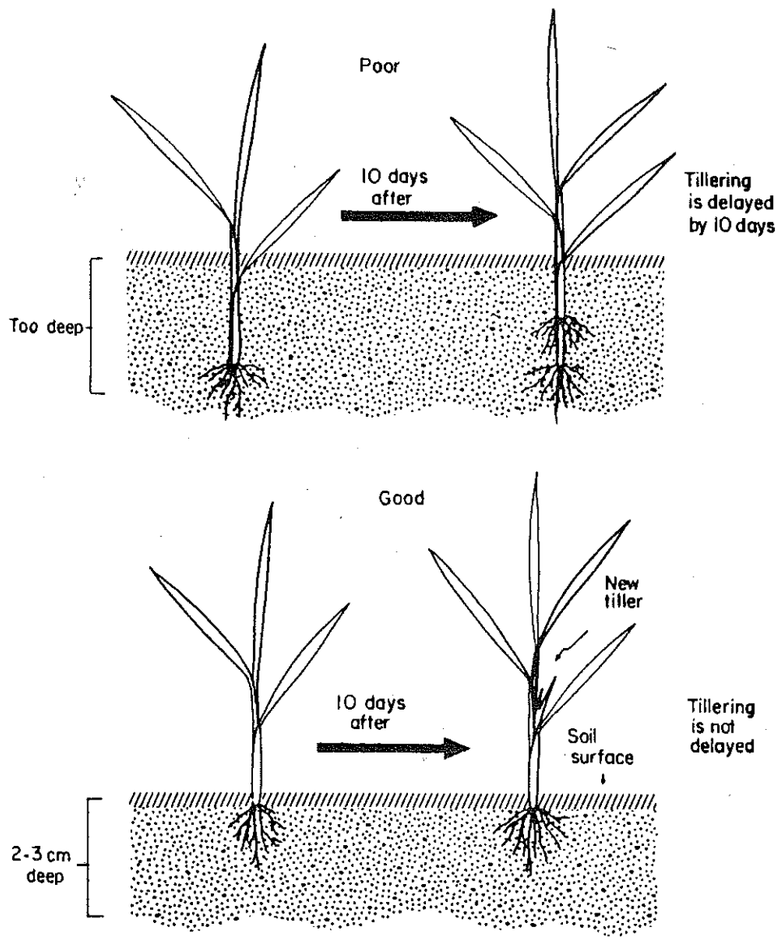


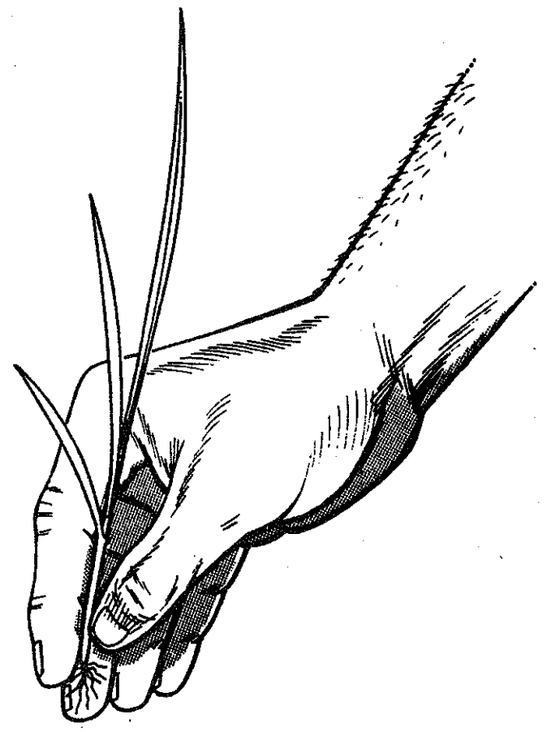
FIGURE 12: Why transplant at the proper depth

Spacing for transplanting

1. For high yielding varieties with optimum dose of fertilizers and for late maturity varieties spacing is 20 x 20 cm.

2. 20 x 10 cm or 20 x 15 cm spacing is appropriate for early season paddy or for late transplanting of the normal rainy season rice. This spacing is also used if a low dose of fertilizers is applied.

3. Missing hills are transplanted within 7-10 days.



UNIT 4
WEEDS AND THEIR CONTROL

Weeds are one of the major causes of low rice yield in Nepal. Loss in yield due to weeds has been estimated at between 10 - 70%. Upland rice has serious weed problems every year throughout Nepal. Weeds benefit from fertilizer application. To obtain more profit from the use of fertilizer, weed control is most essential.

Constraining effects of weeds:

- weeds act as hosts for plant disease and insect pests.
- weeds make land preparation more expensive and time consuming.
- weeds adversly affect the quality of harvested seeds.
- weeds compete with the crop for light, moisture, nutriment and other growth requirements.

Weeds classification:

1. According to life span or growth habit.
   A. Annuals: Plants that live only one year or less.
   B. Binnials: Plants that require two years to complete their life cycle.
   C. Perennials: Plants that complete their life cycle normally in more than two years.

2. According to controlling purpose or leaf characteristics.
   A. Broadleave weeds
   B. Narrow leaved weeds, grass
   C. Sedges

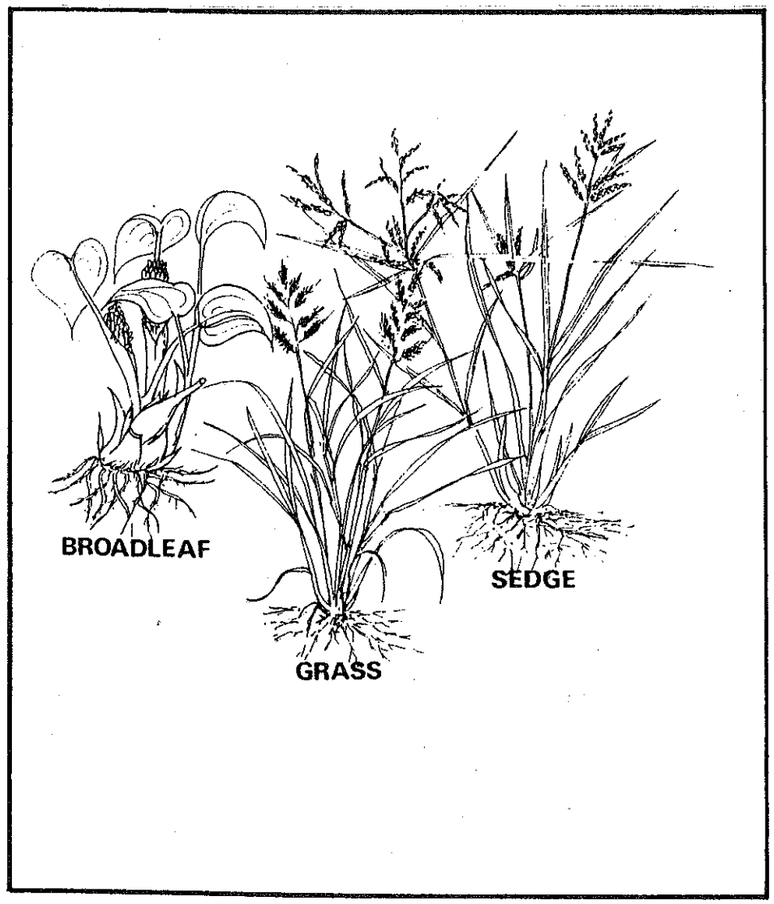


FIGURE 13: Three types of weed flora

Why upland rice has more weeds?

- Uneven plant stand
- Poor growth rate of rice.

Methods of weed control:

1. Prepare the land thoroughly.

2. Practice straight row planting or sowing for early hand weeding or mechanical weeding.

3. Flood paddy at effective water depth of 5-10 cm after 5th to 7th day of transplanting until about the end of the 3rd week.

4. Weed population is reduced by:
   - crop rotation (see page 50 pp)
   - closer spacing of rice plants
   - using transplanted rice instead of direct seeded rice
   - using local varieties instead of modern cultivars

5. Hand weeding: two hand-weedings, one at 25-30 days after planting or transplanting, followed by the second at 30 days after the first weeding.

6. Mechanical weeding: by the use of rotary hoe.

7. Use of herbicides:
   1. For upland rice: - 1 kg a.i. of Benthiocarb or 2 kg a.i. of Butachlor should be sprayed with 300-500 litres of water 3-5 days after seedling.

2. For lowland rice: - When broad leaved weeds are dominant, spray 0.8 kg a.i. 2,4-D IPE granules 4 days after transplanting. Drainage is necessary before spraying, weeding and top-dressing.

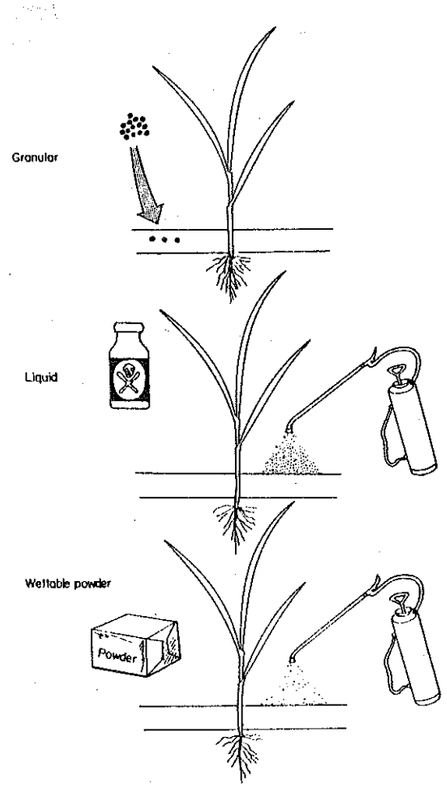


FIGURE 14: Types of herbicides and their application

UNIT 5
RICE-BASED CROPPING SYSTEMS

A rice based cropping system in the paddy lands demands improved varieties of rice which are high yielders as well as high in straw yield, because straw is the principal fodder item during dry periods of the year.

1. Rice-Rice-Wheat	2. Rice-Rice/Gram
3. Rice-Rice/Lentil	4. Rice-Rice-Vegetable
5. Rice-Rice/Lentil + Linseed	6. Mung + Rice-Wheat or Vegetable or Legume
7. Rice-Wheat	8. Rice-Potatoes
9. G.M.-Rice-Wheat	10. Rice-Potatoes-Maize (Spring)
11. Rice-Tori-Wheat	12. Rice-Peas-Maize
13. Jute-Rice-Wheat	14. Jute-Rice-Legumes
15. Rice-Tori-Maize (Spring)	16. Maize-Rice-Wheat
17. Rice-Wheat-Mungbean	18. Rice-Maize (Winter)
19. Rice-Maize-Maize (S)	20. Rice-Tori
21. Rice-Potato + Pea	22. Rice-Maize (W)-Mungbean

/ Relay cropping
- Sequence cropping
+ Mixed cropping or intercropping

TABLE 11: Crop rotation for irrigated areas

1. Rice (Lowland)-Fallow	2. Rice/Lentil
3. Rice/Gram	4. Rice/Linseed or Gram or Lethryrus or Lentil
5. Rice-Tori	6. Rice-Wheat
7. Rice-Barley	8. Rice + Mung
9. Rice + Maize	10. Rice + Maize-Wheat
11. Rice + Cotton	12. Rice + Maize + Redgram
13. Maize (Spring)-Rice	14. Rice (Upland)-Fallow
15. Green manures-Rice	16. Mungbean-Rice

/ Relay cropping
- Sequence cropping
+ Mixed cropping or intercropping

TABLE 12: Rainfed rice-based crop rotations

UNIT 6
RICE SOILS OF NEPAL

Rice is grown from very high fertile to low fertile soils in different climatic conditions in Nepal. Nepalese farmers do prefer to grow rice whereever water is available irrespective of the fertility of soils.

Rice has a very good potentiality in several parts of Nepal and accordingly soils are classified, based on areas, altitude and climatic conditions:

1. Soils of the Terai plain
2. Soils of the Inner Terai valleys
3. Soils of the River valleys
4. Soils of the Hilly lands

Soils of the Terai plain:

Textures are mostly silt loam to silty and soil reaction is acidic to moderately alkaline.

Soils of the Inner Terai valleys (150-800 m):

Texture is sandy loam to silt loam, soil reaction is strongly acidic to neutral.

Soils of the River valleys (300-1400 m):

Texture is sandy loam to silty clay and soil reaction is strongly to slightly acidic and some neutral.

Soils of the hilly lands (1.500-3.000 m):

Texture is loam to silty clay loam. Soil reaction is strongly to slightly acidic.

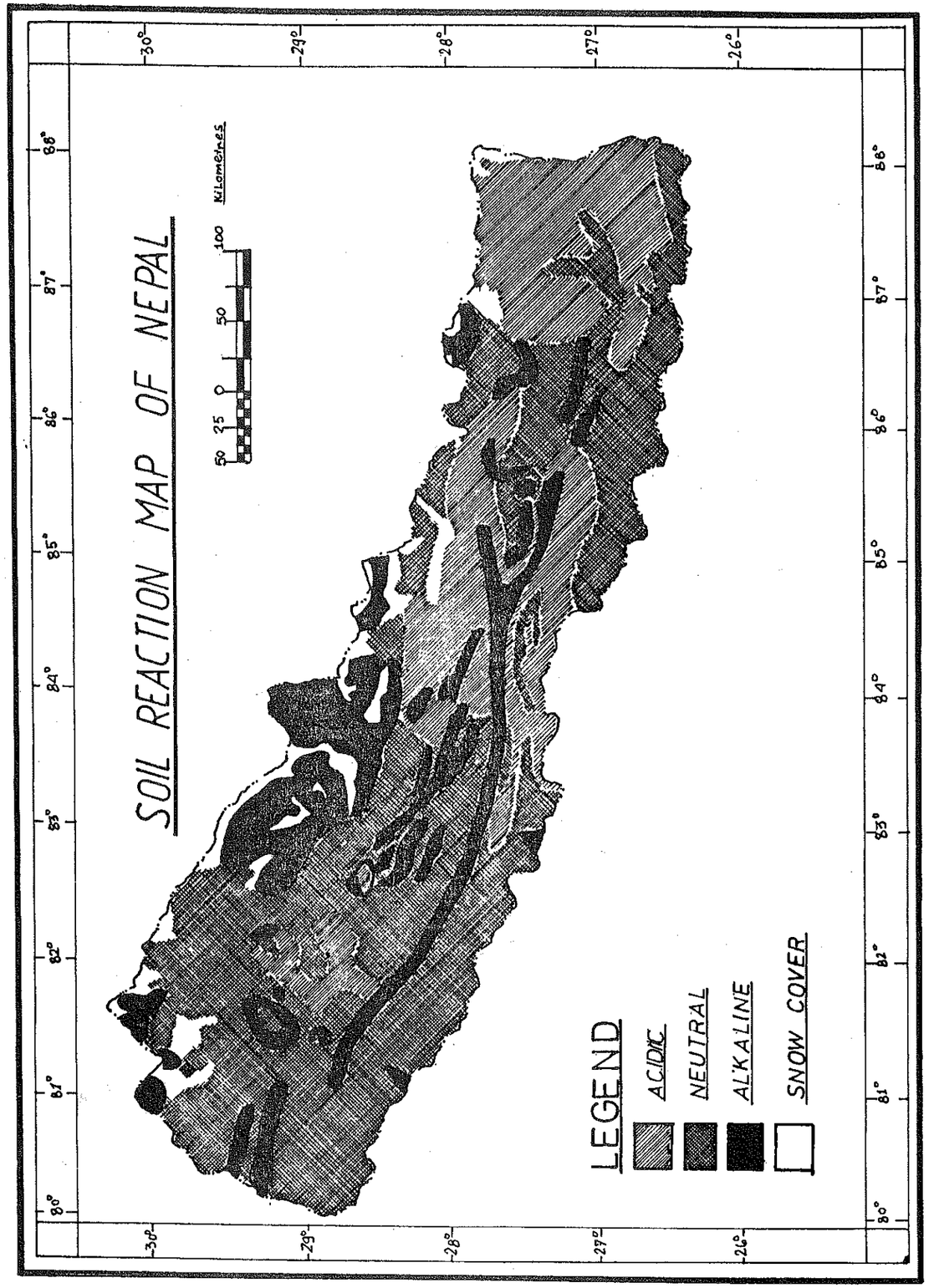


FIGURE 15: Soil Reaction Map of Nepal

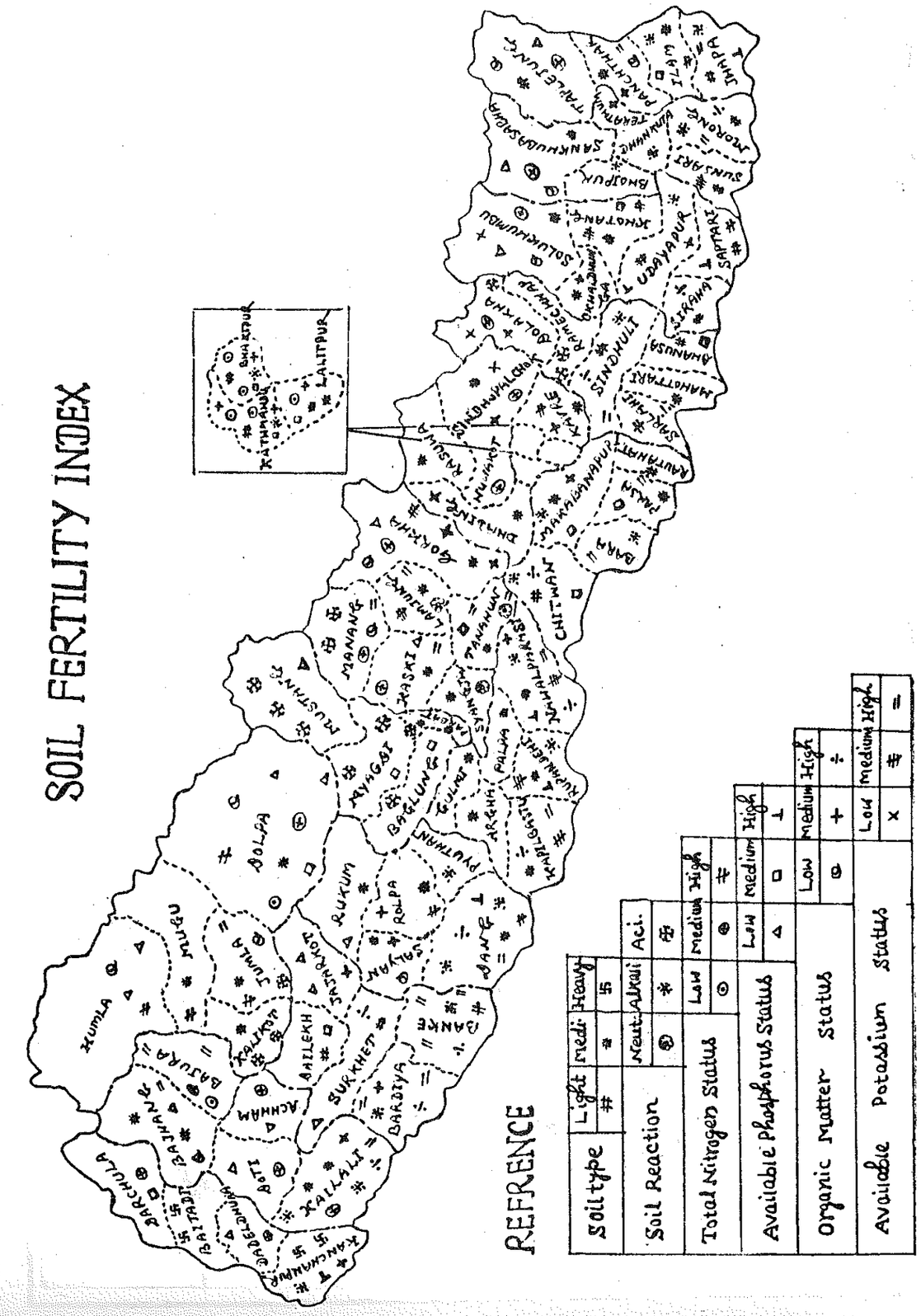


FIGURE 16: Soil Fertility Index of Nepal

UNIT 7
INTEGRATED NUTRIENTS SUPPLY

U7.01 NATURAL SUPPLY AND ORGANIC SOURCES

Natural supply

- Micro-organisms
- Rain water
- River silt
- Decomposition of organic matter
- Micro-organisms
  a) Blue green algae (leo-semar, B.G.A.)
  b) Azotobacter
  c) Azospirillum
  d) Rhizobium species
  e) Phosphobacterium
- Rain water: - Rain does supply an appreciable proportion of nutrients.
- River silt: - River silts of forest origin supply plenty of humus, rich in nutrients for ideal rice growth and profitable yields.
- Decomposition of soil organic matter: - Weeds, tree leaves and left over materials of cropped and uncropped-field contribute a reasonable amount of organic matter. And the combination of all the above four sources supply nitrogen only in the range of 40-80 kgN/ha.

Organic sources

There are two types of organic sources of nutrients supply: Bulky organic manure and concentrated organic manures.

Bulky organic manure:

a. Farm yard manure (FYM)
b. Compost
c. Night soil
d. Sewage and sludge
e. Green manures
f. Kalimati
g. Biogas slurry

Concentrated organic manures:

a. Oil cakes and various types of cakes available in the market.
b. Poultry manures
c. Bone meals
d. By-products of animals

U7.02 HOW TO PREPARE BULKY ORGANIC MANURE

Farm yard manure and compost are prepared either in pits or in heaps depending on altitude and climatic conditions (see FIGURE 17 and 18).

Starter (culture) is used in both methods. Starter consists of:

- small amount (½ kg) of fertilizer
- small amount of complesal or phosphatic fertilizers
- small amount of lime
- small amount of decomposed organic manure
- small amount of ashes, garden or surface soil
- mix with water and spray on pit and heap.

FIGURE 17: Compost: Pit method

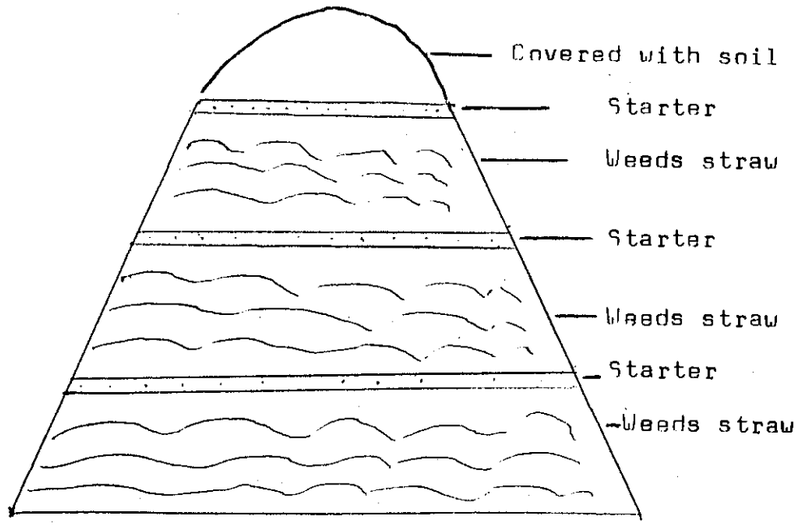


FIGURE 18: Compost: heap method

Advantages of pit method:

1. Compost making is easier in the dry season.

2. If temperature and moisture is favourable composting is easier in a pit.

3. From the point of view of sanitation it is better to prepare it in a pit.

4. When there is no scarcity of land and no problem of water table, the pit method is better and more economical.

Advantages of heap method:

1. In the rainy season the heap method is preferable.

2. When there is a problem of a high water table and scarcity of land the heap method is better.

3. Mixing and turning the composting material is easier.

4. It is a laborious method but can be prepared in less time.

U7.03 GREEN MANURES

a. Dhaincha (Sesbania aculeata and sesbania rerstrata)

b. Azolla (Azolla pinnata)

c. Sunhemp (Crotalaria juncea)

d. Local green manures e.g.:

- Ausro
- Titepati
- Khirra
- Taramandal
- Siris
- Ankhetare
- Bhogate (wild, not of citrus family)
- Banmara
- Water hyacinth (Dal Kachu)

Azolla

Azolla is a water fern. This is commonly found in the marshy low land, ditches, river banks, canal sides, in muddy and standing water in all mid hills and Terai areas of Nepal. The growth of azolla is very rapid in tropical and temperate water having 2 to 3 days doubling capacity. In unmature condition azolla is of green colour and later, on maturity, it turns red in colour.

Anabaena azollae that live in the azollas upper lobes have the nitrogen fixing ability. By using azolla in the rice field before or after transplanting, about 30 to 40% of the rice yield can be increased without applying any chemical fertilizer.

Plant nutrients present in azolla are nitrogen 4.5%, phosphorus 1.6%, potassium 1% with all secondary as well as trace elements also present in a small amount.

When and how to apply

- before transplanting of rice
- after transplanting of rice
- combine both if possible, it gives very good results.

Before transplanting: - Azolla is grown in the field one month beforehand and incorporation is done by ploughing at the time of transplanting the rice seedlings.

After transplantation: - The azolla is spread on the field within 2-3 days of transplantation of paddy and incorporation is done at the time of weeding.

Seed multiplication of azolla

- dig a pond near to the house
- put some azolla into the pond
- put some phosphatic fertilizer in the pond for better growth
- save the azolla from insect and pests by using some pesticide and insecticide
- save the azolla from flooding
- transfer the azolla to the paddy field when it reaches the red colour stage.

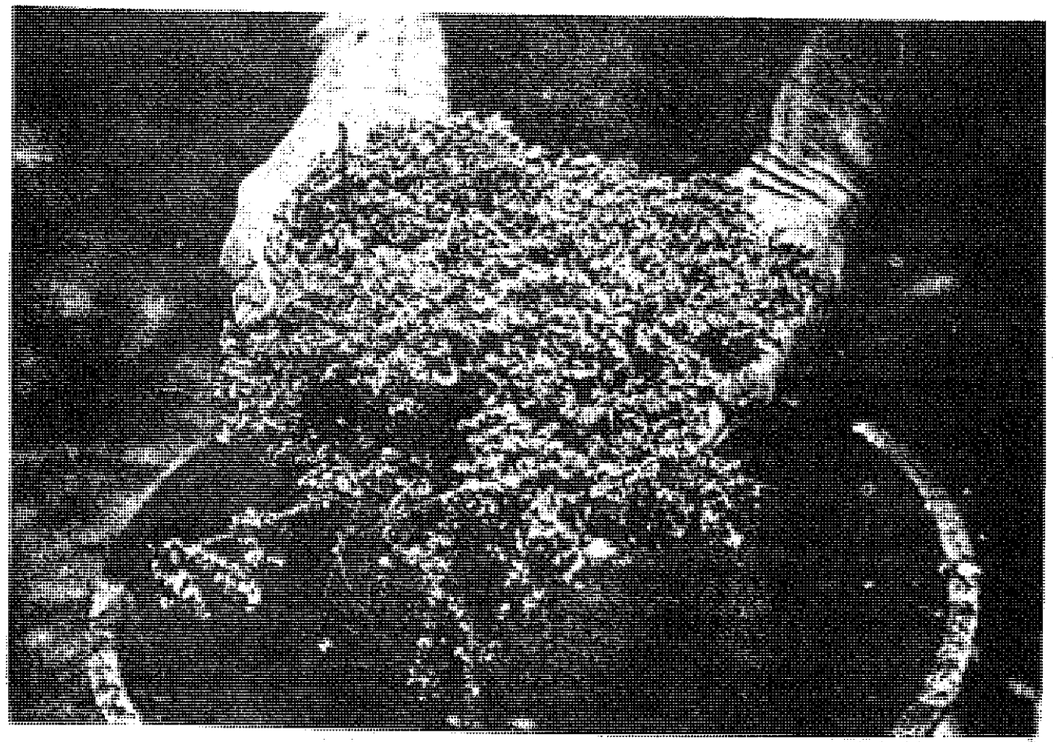


FIGURE 19: Azolla

Advantages of Azolla

1. Azolla is easier to multiply in paddy culture if water is available.

2. The Nitrogen content is quite high as compared to other green manures.

3. The multiplication rate of Azolla is very fast; it doubles in 3-5 days.

4. Mixing and decomposition in the rice field is fast.

5. Recovery or uptake of nutrients by rice plants is very quick.

6. Azolla can be multiplied two to three times and used as a green manure even in one rice crop.

Advantages of Dhaincha

1. The total green matter product as a manure is quite high as compared to other green manure.

2. It has good nutrients for rice as well as soil conditioners (saline and alkali soils).

3. It is very useful for rice, if water is available during incorporation.

4. Because of leguminous green manure it has additional advantages for the succeeding crops.

UNIT 8
ESSENTIAL NUTRIENTS THAT THE RICE PLANT NEEDS

U8.01 GENERAL

There are sixteen essential elements for rice.

1. Six are major: Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorus and Potassium.

2. Three are secondary: Calcium, Magnesium and Sulphur.

3. Seven are trace elements: Zinc, Iron, Copper, Molybdenum, Boron, Manganese and Chlorine.

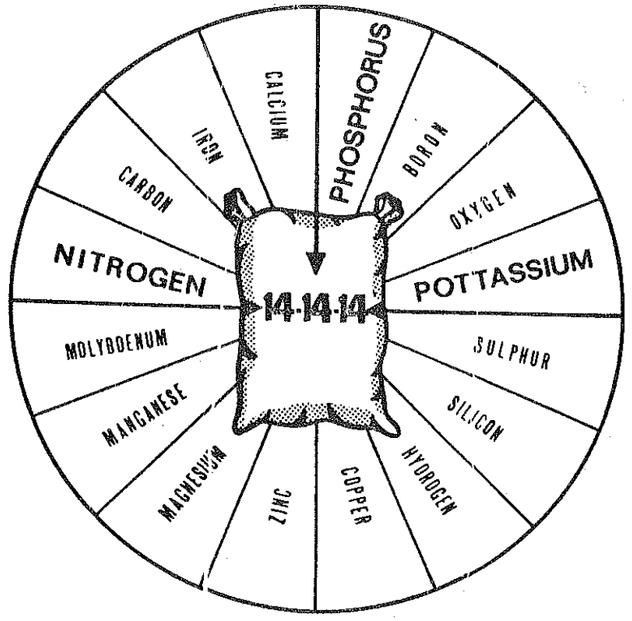


FIGURE 20: Nutrients that the rice plant needs

U8.02 FUNCTIONS AND DEFICIENCY SYNDROMES OF NUTRIENTS

Rice plants need a large amount of nitrogen at the early and mid-tillering stages to maximise the number of panicles.

Functions of nitrogen (N)

- accelerates growth and gives a dark green appearance as a component of chlorophyll.
- promotes rapid growth or increased height and tiller number.
- increases leaf area index (LAI) and size of grains.
- gives more spikelets per panicles and also filled spikelets.
- increases protein content in the grains and also improves microbial activity in the soil.

Deficiency syndromes of nitrogen

- stunted growth and limited number of tillers.
- narrow and short leaves which also become yellowish green.
- old leaves become light straw colour and finally die.

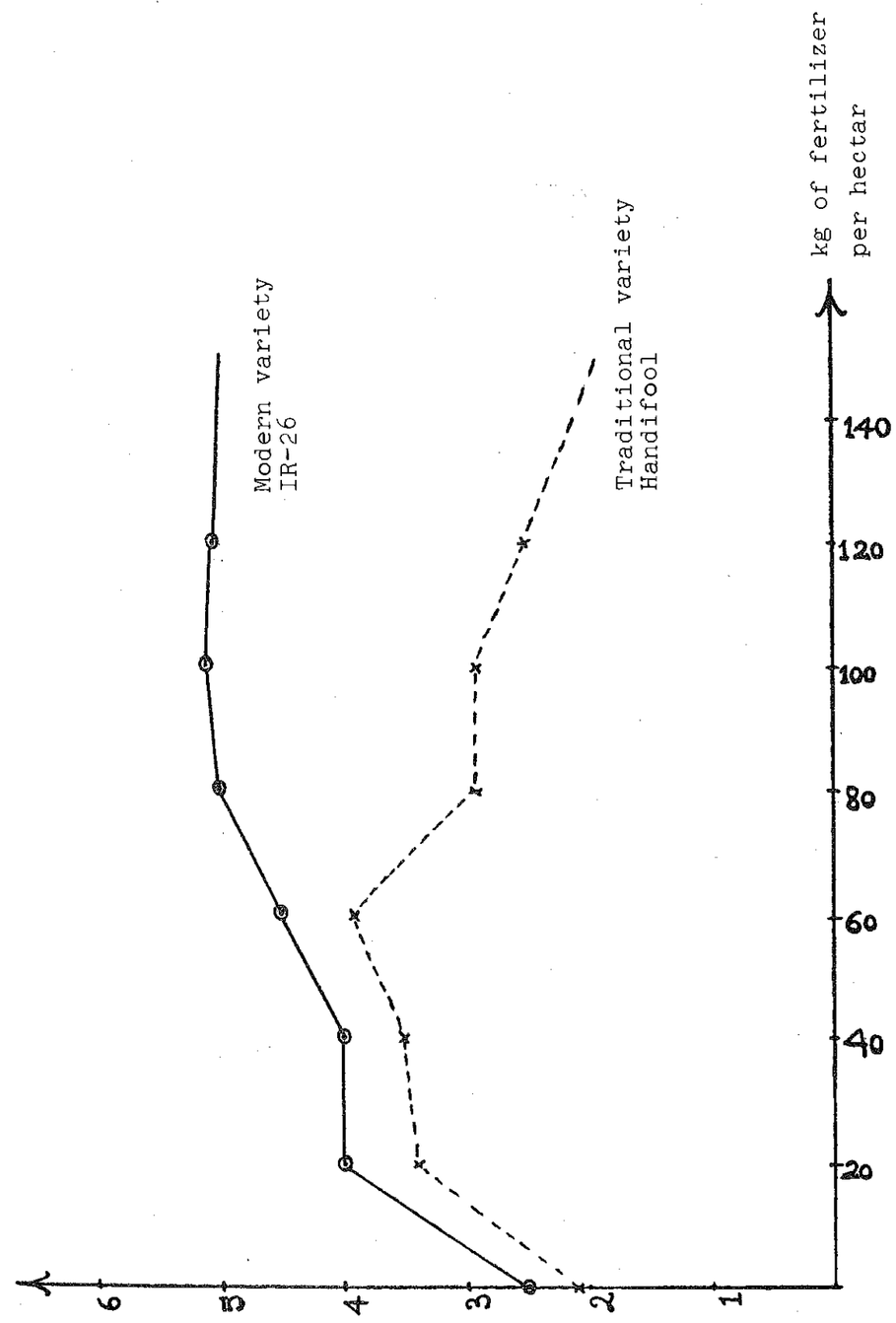


TABLE 13: Effect of N on modern and traditional variety

Functions of phosphorus (P)

- it stimulates vigorous root development and supports anchorage for the plants.
- hastens earlier flowering and ripening.
- encourages more active tillering.
- promotes good grain development.

Deficiency syndromes of phosphorus

- dwarf plants with limited number of tillers.
- narrow and short leaves of a dirty dark green.
- purple or red colour developes on leaves.
- delayed ripening.
- high percentage of empty grains.
- absence of algae in the water covering the field.
- low tolerance to cold weather.

Functions of potassium (K)

- supports tillering and increases size and weight of grains.
- stimulates phosphorus response.
- develops resistance to diseases and adverse climatic conditions.

Deficiency syndromes of potassium

- drying of leaves on the tips and along the margins.
- short, droppy and dark green leaves.
- irregular necrotic spots on the panicles.

Functions of sulphur (S)

- Helps in chlorophyll formation.
- essential for protein, enzymes and certain volatile enzyme synthesis.
- promotes root growth and helps in seed formation.

Deficiency syndromes of sulphur

- similar to nitrogen deficiency but in the case of sulphur the plants are dwarf and bushy in nature, leaves are thick and coming from central whorls.
- the whole plant becomes chlorotic at the tillering stages.
- reduced plant height and tiller number.
- very few shorter panicles and reduced number of spikelets per panicle at maturity.

Functions of zinc (Zn)

- constituent of several enzymes.
- helps in production of auxin.
- involved in nitrogen metabolism.
- helps in water uptake and water relationship.

Deficiency syndromes of zinc

- stunted growth and reduced number of tillers.
- poor development of roots and drying of leaves.
- the midribs of the younger leaves, especially the base, become chlorotic.
- brown blotches and streaks in lower leaves.
- uneven growth and delayed maturity in the field.

- symptoms generally appear as brown streaks and blotches on the lower leaves between 2-3 weeks after transplanting.
- severely affected plants die and most of the affected plants recover within 35-40 days.
- zinc deficiency is also known as Khaira disease physiologically in India.

Functions of Iron (FE)

- essential for chlorophyll formation.
- protein synthesis.
- several metabolic reactions.
- involves several oxidation-reduction reactions.

Deficiency syndromes of Iron

- the whole leaves become chlorotic and finally a whitish colour.
- newly emerging leaves become chlorotic if the iron supply is cut abruptly.

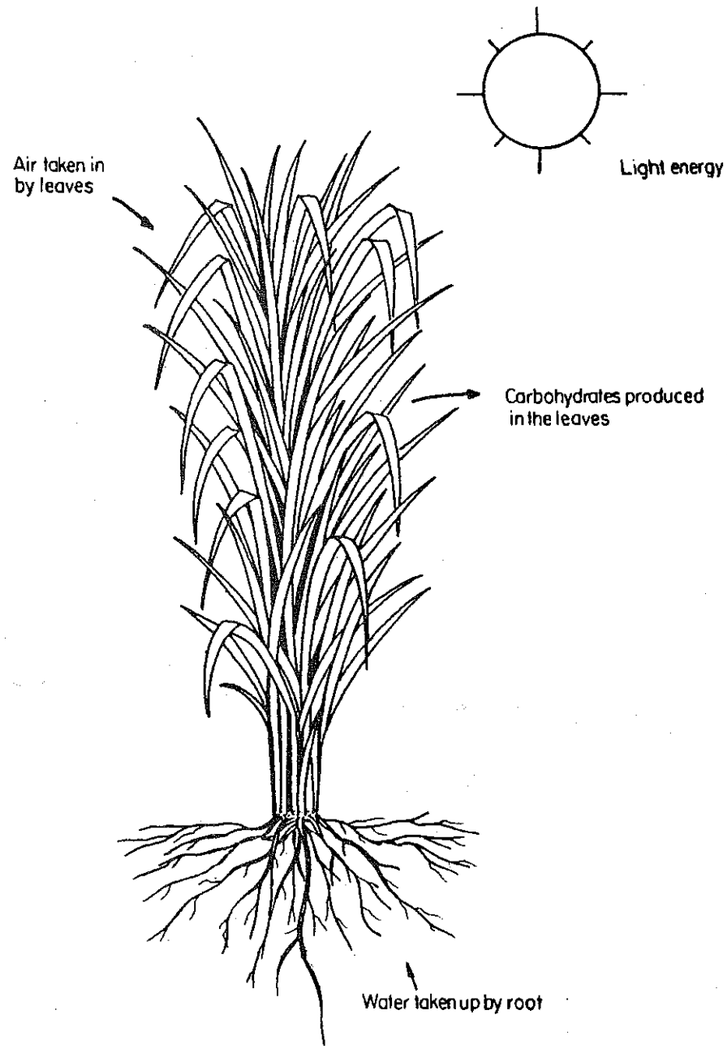


FIGURE 21: Nutrients up-take by rice plant

Function of copper (Cu)

- essential to oxidation.
- reduction system of rice plant (photosynthesis, respiration and enzyme system).
- helps to utilize iron in chlorophyll formation.

Deficiency syndromes of copper

- leaves become bluish-green and then chlorotic near the tips.
- chlorosis develops downwards along both sides of the mid-rib followed by dark brown necrosis of the tips.
- the new emerging leaves fail to unroll and maintain a needle-like appearance along the entire length of the leaf or occasionally along half of the leaf.

Function of molybdenum (Mo)

- the role of molybdenum in the rice plant is related to reduction of nitrate to nitrite. No deficiency symptoms have been observed so far in the rice plant, plants absorb molybdenum from soil minerals.

Function of boron (B)

- works as a catalyst in the rice plant system.
- regulator of physiological functions such as nitrogen metabolism and nutrient uptake.

Deficiency syndromes of boron

- plant height is reduced.
- tips of emerging leaves become white and rolled, as in the case of calcium deficiency.

- growing point may die in severe cases, but new tillers continue to be produced.

Functions of manganese (Mn)

- helps in photosynthesis and in oxidation-reduction process.
- activator of serveral enzymes, such as oxidase, peroxidase, dehydrogenase, decarboxylase, and kenase.

Deficiency syndromes of manganese

- stunted growth but with a normal number of tillers.
- internal chlorosis on the leaves.
- chlorotic streaks spreading downward from the tip to the base of the leaves, which become dark brown and necrotic.
- newly emerging leaves are short, narrow, and light green.

Functions of silicon (Si)

Though the role of silica (silicium) in the physiology of the rice plant is still obscure it has certain functions in plants.

- improves plant type and makes leaves stand more erect.
- develops resistance to diseases and lodging.
- promotes roots respiration and translocation of potassium.

Function of chlorine (Cl)

- essential in photosynthesis.

UNIT 9

REQUIREMENT OF MANURE AND FERTILIZERS FOR HIGH YIELD OF RICE

U9.01 GENERAL

The yield of rice depends on management of its nutrition right from the nursery bed to maturity in the field. Here mainly four factors have been considered for fertilizer requirement for obtaining a higher rice yield.

1. Season of cropping

- rainy season
  - upland
  - lowland
- dry season

2. Fertility status of soils

- upland
  - rainfed
  - irrigated
- lowland
  - rainfed
  - irrigated

3. Genetic potentiality of variety.

4. Benefit from fertilizer applied.

Fertilizer requirement for modern and traditional varieties

Modern variety (IR-26)	Traditional variety (Handifool)
- slow seedling development and lesser initial nutrient uptake.	- rapid seedling development and a quick initial nutrient uptake.
- short errect leaves of medium width.	- broad, long drooping, pale green leaves.
- short internode, thick, stiff and short cum length.	- long internode, thin, tall and culms.
- heavy tillers and short height less than 100 cms or 100 cms	- less tillers, height is more than 100 cms.
- more panicles and filled grains.	- less panicles and spikelets and filled grains.
- yield more at lesser spacing (10 x 10 cm or 20 x 20 cm)	- yield best at wide spacings (35 x 35 or 50 x 50 cm)
- does not lodge and responds more to high level of N.	- when grown at high fertility levels and when solar radiation is low, lodges in cloudy monsoon season when grown in fertile soil.

Fertilizer requirement due to climate

- yield of modern varieties does not depend on nutrient only but it also depends on climate.
- yield depends on day and night temperature irrespective of day length.

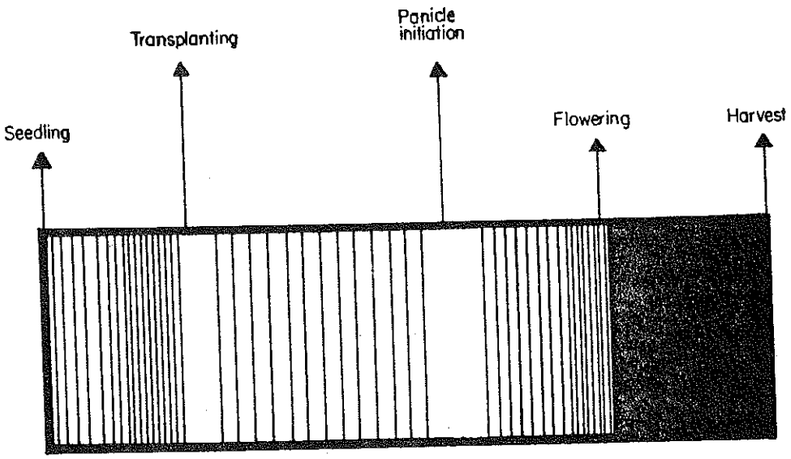
U9.02 NITROGEN NUTRITION OF RICE

Nitrogen application at diffent stages of rice growth

During transplanting: More than 50% N as basal should be applied when

- low air and water temperature at transplanting.
- early maturing varieties.
- low natural supply of nitrogen (poor tillering).
- wide spacings.
- poor tillering varieties.
- soil with a very high C.E.C. (cation exchange capacity).

During tillering: For optimum photosynthesis growth and tillering nitrogen must be around 4% or above on the leaves. So, at this stage 25% (¼) of the recommended dose must be applied to rice crop.



The lighter the shade the better the time of application

● The most efficient times for applying nitrogen fertilizers are at transplanting and at panicle initiation.

FIGURE 22: Nitrogen fertilizer application at correct growth stage

During panicle initiation: At this stage 25% of the recommended dose of N should be applied because of

- late maturing varieties.
- heavy tillering varieties and close spacing (10 x 10 cm).
- high temperature at transplanting.
- high initial natural supply of N in the soil (good tillering).

Emphasis on more than two nitrogen applications

- heavy rates of N application (over 100 kg N/ha).
- late maturing varieties.
- light soils and high rainfalls.

Foliar application

- for quick response on the vigorous vegetative growth.
- for dry land conditions when water is scarce.
- when readily available forms of neutral or non-sulfate fertilizers are at ease.
- to get a profitable return in a shorter period of time.
- never spray ammonium sulfate as it causes burning on leaves.

Farmers generally prefer ½ of N as basal and ½ top dress at profuse tillering stage.

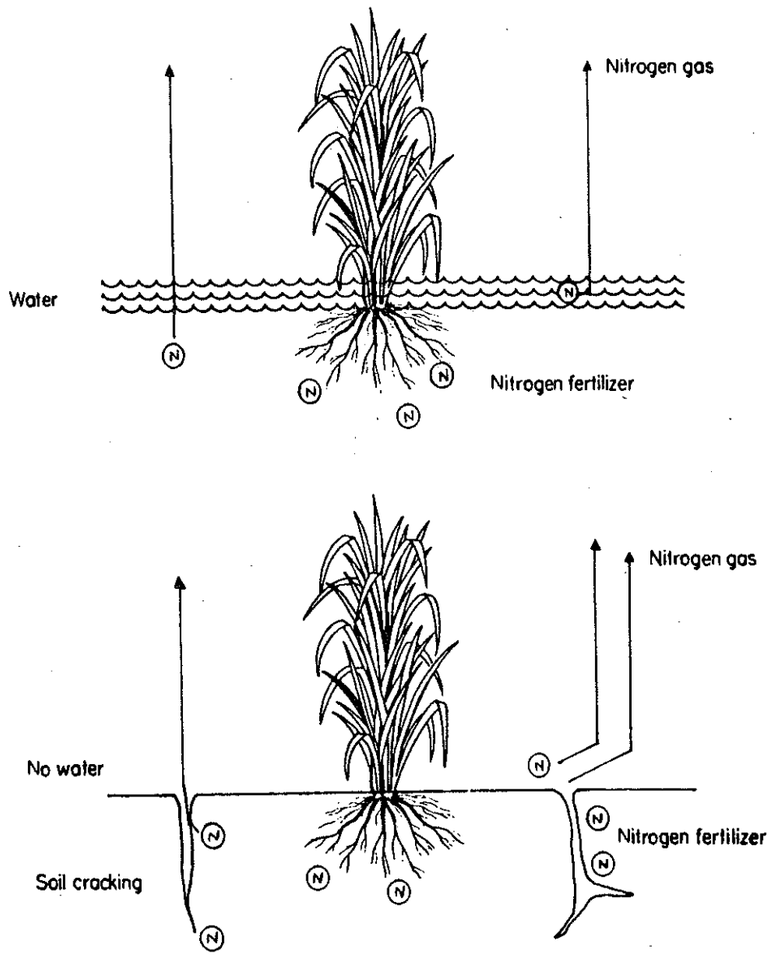
Fate of nitrogen in lowland rice field

The recovery of applied nitrogen fertilizer seldom exceeds 45% in the rice field because of lowest utilization efficiency of nitrogen in comparison with other crops.

There are 8 forms of loss of N in the rice field:

1. Losses due to ammonia volatilization, escape as ammonia gas.
2. Losses due to nitrification, conversion of ammonium to nitrate.
3. Losses due to denitrification-conversion of nitrate to nitrite.
4. Losses due to leaching - downward movement of nitrate.
5. Losses due to erosion-washing out.
6. Losses due to immobilization-insoluble form.
7. Losses due to fixation-unavailable form.
8. Losses due to crop removal.

FLOODED PADDY PREVENTS LOSS OF FERTILIZER AND INCREASES YIELD



- On and off flooding results in great losses of nitrogen to the air.
- Nitrogen applied to flooded soil is changed to a different form by the air. This form is easily changed into gas and lost into the air.
- Water keeps the air from moving into the soil. The less air in the soil the less change in nitrogen to gas form. Repair levees to prevent water loss.

FIGURE 23: Prevent the field from drying out

Advantages of submerged paddy field for nutrients uptake

- standing water protects the rice plant from cold damage.
- the natural supply of nutrients to the rice crop is more favourable.
- inherent soil phosphorus is more available because of its solubilization under submerged conditions.
- the emergence of weed is reduced.
- submergence may enhance the fixation of nitrogen by blue-green algae and other micro-organisms.
- on flooding the pH values of the acid soils increase.

How to increase the efficiency of nitrogen fertilizer

By knowing the fertility status of soils plant analysis data and crop response to yield, we can predict the fertilizer doses and it can be used very judiciously.

- adopt high yielding cultivars and maintain proper spacing.
- use judicious doses of fertilizer.
- apply fertilizer at proper growth stages and in the centre of the rows.
- try to keep the fields flooded.
- use the fertilizer at the proper depth (4-6 inch depth).
- adopt slow releasing nitrogenous fertilizers like SCU (Sulfur coated urea), IBDU (Isobutylidene diurea), mudballs, super-granules (brickets), prilled urea, laccoated urea, resin coated urea, wax-gum coated urea, cakes of different kinds mixed with urea, coaltar mixed with urea, urea form, nitrification inhibitors.

- maintain weed free fields.
- take timely plant protection measures.

Urea and cakes-mix together, 100 kg urea + 10 - 15 kg cakes + 1 kg coaltar + 1 - 2 litres kerosene oil.

How loss of urea and Ammonium sulfate can be minimised

Loss of urea and ammonium sulfate can be minimised if the rice fields are re-irrigated after three days of fertilizer application.

Time in hours	% of urea subject to leaching (runoff)
0	87
6	62
24	38
30	14
48	6
54	5
72	6

TABLE 14: Rate of loss of urea if applied improperly

- top dressing in standing water is not very effective.
- urea because of amide form Co $(NH_2)_2$ is not fixed by the soil colloid so there is more risk of leaching than ammonium sulfate in the beginning.
- for better efficiency first drain the field, then top dress urea and wait for a few days (2-3 days) and then allow irrigation in the field.

U9.03 PHOSPHORUS NUTRITION IN RICE

The major source of phosphorus (P) nutrition in rice is from weathering of phosphorus bearing minerals and the decomposition of organic matter. Under sub-soil most forms of iron phosphate release phosphorus and make it available to the plants.

Phosphorus response

Applied phosphorus has no distinct response in grain yield preferably in lowland rice. The uptake of phosphorus is more in upland conditions provided that the pH is low (acidic condition).

Time of phosphorus application

- because of less solubility always apply P as basal dose.
- P applied during the tillering stage is not efficient for grain production.
- split application of P is not profitable.

Methods of P application

- broadcasting at puddling immediately before planting.
- drilling of side dressing at puddling before planting.
- dipping the seedlings in a slush of mud with phosphorus.

Rate of P application

- rate of P depends on fertility of soils.
- depends on upland and lowland soils.
- requirment of the type of varieties (local and improved ones).

- methods of application whether broadcasted, side dressing or drilling (10 - 20 cm depth).
- type of P fertilizers and their availability (different kinds of fertilizers contain different amounts of P).

U9.04 ORGANIC AND GREEN MANURES

Different sources of organic manures should be used in sufficient amount during land preparation for direct seeded and transplanted rice whereas different sources of local green manures should be used preferably during the transplanting of rice. There are some green manures like Azolla which can be used during and after transplanting the rice. It can be grown in rice fields at any time of the year provided that water is available in the field (see also U7.03, page 59 of this Manual).

Advantages of organic and green manures:

- support plant growth
- increase yield
- improve soil structure
- improve water holding capacity
- improve aeration of soil
- increase microbiological activity
- supply all necessary plant nutrients
- has residual effect on following crops

U9.05 RESPONSE TO POTASH (K)

- response to K is not distinct in rice as compared to N and P.
- under intensive cropping K is more necessary.
- in sandy soils response to K is low.
- in poorly drained soils response to K is better.
- rate varies according to rice variety.

Time of K application

K basal application when:

- using heavy tillering varieties and close spacing.
- early maturing varieties.
- high CEC soils (Cation exchange capacity, if Ca and Mg are high).
- varieties tolerant to iron toxicity.
- light soils highly deficient in K.
- soils all the year round under flooded conditions.
- dry season crops.

K top-dressing

when:

- medium to poor tillering varieties.
- late maturing varieties.
- acid sulfate soils.
- varieties sensitive to P deficiency and iron toxicity.
- alkaline soils with danger of zinc deficiency.

- wet season crops (rainy season crops).
- methods and rates are similar to phosphorus.

U9.06 ZINC AND OTHER NUTRIENTS

After nitrogen and phosphorus deficiency, zinc deficiency now ranks first among the nutritional disorders that limit the grain yiel of rice. Now zinc deficiency is becoming a problem in Nepal.

Causes of zinc deficiency in soils

- replacement of tranditional varieties by modern varieties.
- high organic matter content in soils.
- water logging conditions (Dhab Khet).
- in high pH calcareous soils (Kameromato).
- submerged acid soils as a result of the rice in pH after flooding.
- recently levelled soils.
- replacement of ammonium sulfate by urea causing a temporary rise in soil pH.
- high use of P fertilizers.
- increased use of concentrated fertilizer not containing zinc.
- in cold and humid areas.

Management of zinc fertilizer

(zinc during nursery bed land preparation and seedlings treatment see page 28)

During growing season

- zinc deficiency starts from 10 - 40 days after transplanting.
- use foliar application of zinc sulfate and zinc chloride 5 kg Zn/ha and 2.5 kg lime in 1000 litres of water, it will be repeated 3-4 times at an interval of 10 days.
- use sticker also if possible.
- apply foliar spray with 0.5% $ZnSo_4.7H_2O$ at 5-7 days before panicle initiation.
- use of zinc on the seed, soil or water but surface applications are as effective as incorporated zinc.
- surface application of zinc is more effective for water sown rice than the incorporation of zinc in calcareous soils.
- drain the zinc deficient plot for some time so that it will increase zinc solubility.
- in dry land and directly sown rice 15-20 kg $ZnSo_4$/ha should be applied during land preparation.

Other nutrients in rice

Iron, copper, manganese, boron and molybdenum are not needed much in rice crops. Nepalese rice soils suffer more from iron, copper and manganese toxicity than deficiency. Sulfur is also a problem in some rice fields but it is maintained through sulfur containing fertilizers like ammonium sulfate, ammonium sulfate nitrate and also from phosphatic fertilizers like single super phosphate. Iron manganese and hydrogen sulfide toxicity and potash deficiency cause bronzing physiologically.

UNIT 10
FERTILIZER CALCULATIONS

Every one should know how much fertilizer should be used in a paddy crop. So the actual quantities of fertilizer required can be calculated by using the following formula.

Let Recommended dose = D
Desired area = A
Hectare = 10,000 m^2 or 20 ropani or 30 Katha.
Fertilizer material = M
Actual nutrients % in fertilizer material = N

Now For square meter		For ropani		For Katha
$M = \frac{D \times A \times 100}{N \times 10{,}000}$	or	$\frac{D \times A \times 100}{N \times 20}$	or	$\frac{D \times A \times 100}{N \times 30}$
$\frac{DA}{100\ N}$	or	$\frac{5\ DA}{N}$	or	$\frac{10\ DA}{3\ N}$

Example: The recommended dose of fertilizer for upland rice variety MW-10 is 80-30-20 NPK/ha and the sources of fertilizer are urea, Triple super phosphate and muriate of potash and the area to be fertilised is 500 m^2 or one ropani, or 1.5 Katha. The soil test values are: nitrogen content is low, phosphorus content is medium and potash content is high. The condition for fertilizer recommendation is the full recommended dose if the content of nutrient is low. If the nutrient content is medium the dose becomes half of the recommended dose, and if the nutrient content is high then the dose is one fourth of the recommended dose. So finally our recommendation is now 80-15-5 NPK/ha.

For nitrogen from urea

$M = \frac{D \times A}{N \times 100}$	or	$\frac{5 \times D \times A}{N}$	or	$\frac{10 \times D \times A}{3 \times N}$
$M = \frac{80 \times 500}{46 \times 100}$	or	$\frac{5 \times 80 \times 1}{46}$	or	$\frac{10 \times 80 \times 1.5}{3 \times 46}$

M = 8.7 kg urea

For triple superphosphate

$\frac{D \times A}{N \times 100}$	or	$\frac{5 \times D \times A}{N}$	or	$\frac{10 \times D \times A}{3 \times N}$
$\frac{15 \times 500}{48 \times 100}$	or	$\frac{5 \times 15 \times 1}{48}$	or	$\frac{30 \times 15 \times 1.5}{3 \times 48}$

= 1.5 kg TSP

For muriate of potash

$\frac{D \times A}{N \times 100}$	or	$\frac{5 \times D \times A}{N}$	or	$\frac{10 \times D \times A}{3 \times N}$
$= \frac{5 \times 500}{100 \times 60}$	or	$\frac{5 \times 5 \times 1}{60}$	or	$\frac{10 \times 5 \times 1.5}{3 \times 60}$

= 416 gm MP

For foliar spray

1. Suppose 2% of urea is to be sprayed in the rice field. Then, quantity of fertilizer needed

   = 20 gm of urea/litre of water or 2 gm urea/100 ml of water.

2. How much urea is needed for 2% solution of urea in 3 litres of water?

$$\text{Solution} = \frac{\text{Desired \% x water in litre x 1000 ml.}}{100}$$

$$= \frac{2 \times 3 \times 1000}{100} = 60 \text{ gm urea.}$$

Definition of soil status regarding nutrients supply

The soil is categorized as low, medium and high based on nutrient status.

Name of nutrients	Low	Medium	High
Nitrogen %	Less than 0.1	0.1 - 0.2	above 0.2
Phosphorus kg/ha	Less than 30	30 - 55	above 55
Potassium kg/ha	Less than 55	55 - 110	above 110
Organic matter %	Less than 2.5	2.5 - 5	above 5

TABLE 15: Definition of nutrient status of soil

UNIT 11
SOIL AMENDMENTS

For reclamation of acidic, alkaline and saline-sodic soils, some ameliorative materials from organic and inorganic sources are used. The materials applied for improvement of the soils are called soil amendments.

Two types of soil amendments

(1) Organic amendments (2) Inorganic amendments

Organic amendments:

- bulky organic manures such as FYM (Farm Yard manure), compost, green manures, weed and crop residues, molasses, sugar factory pressmud and afforestation.

Inorganic amendments:

- agriculture lime, gypsum, zinc sulfate, sulfuric acid, sulfur, ferrous sulfate, aluminium sulfate, lime sulfur.

For acidic soils:

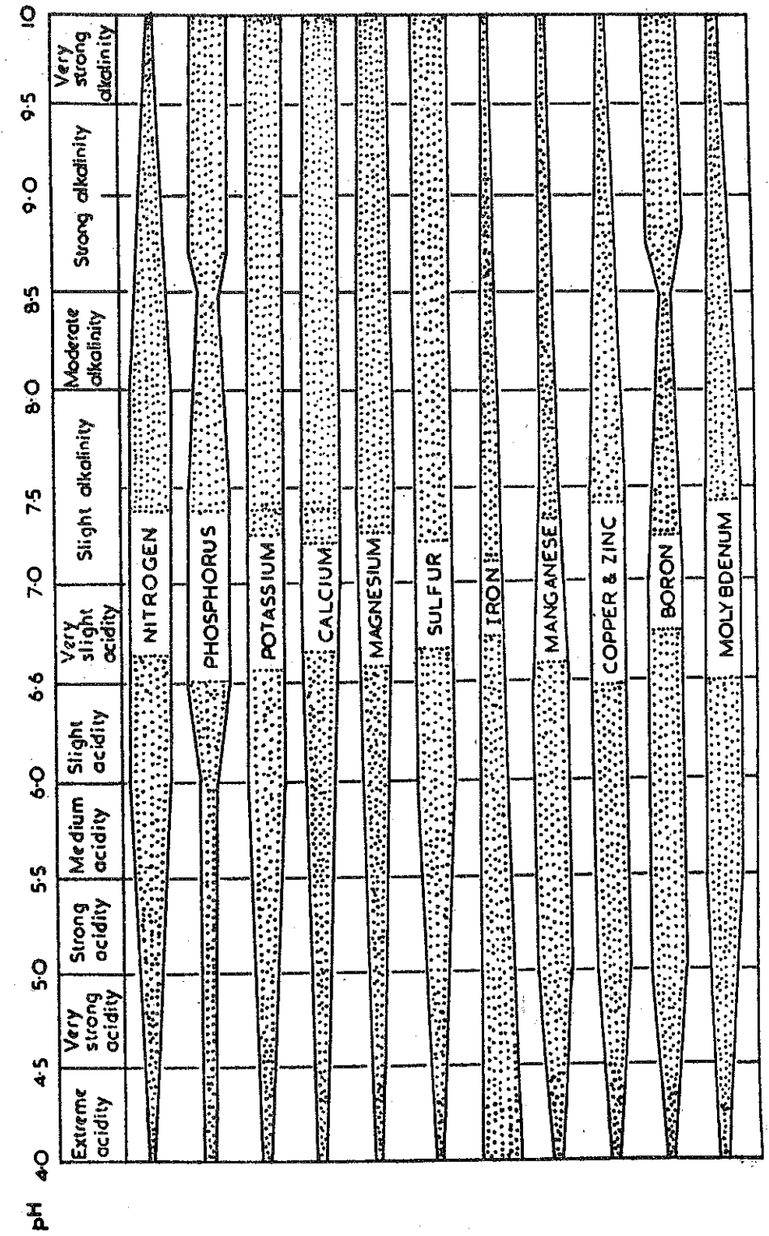
- use agriculture lime, lime stone or locally prepared lime in the form of powder 2-3 weeks before sowing or transplanting of rice.
- mix the lime with the soil by ploughing and irrigating the field.
- the amount of lime depends on pH of the soil, texture, surface area and type of clay minerals, organic matter content and CEC of the soils.

- liming should be practised subject to frequent soil tests (preferably pH test).
- also use sulfur-free mineral fertilizer in the soil.

For alkaline soils:

- use gypsum ($CaSo4.2H_20$) as lime.
- apply molasses and sugar factory pressmuds.
- use 20 - 30 kg/ropani (400 - 600 kg/ha).
- grow green manures like Dhaincha and other green manure.
- apply bulky amounts of organic manures like FYM and compost and other organic manures.
- use sulfur and sulfur containing fertilizer such as ferrous sulfate, ammonium sulfate, aluminium sulfate, lime sulfur, also sulfuric acids.
- use of zinc sulfate helps in micronutrients and decreases pH of the soils.

Fortunately our Nepalese soils are not very alkaline. Acidic soils are found more in the hills particularly in high rain fall areas. So with little constant efforts of lime and liming materials use, problems can be rectified within a short period of time. A brief view of acidic and alkaline soils is shown in the soil reaction map of Nepal (see page 53).



TABEL 16: Nutrient availability as influenced by soil reaction

UNIT 12

NUTRITIONAL COMPOSITION OF MANURES

Nutritional composition of some organic manures

Source	Nitrogen (N%)	Phosphorus (P_2O_5%)	Potash (K_2O%)
FYM	0.5	0.25	0.5
Compost	0.5	0.15	0.5
Night soil	5.5	4.0	2.0
Sewage and sludge	1.5-3.5	0.75-4.0	0.3-0.6
Dhaincha (Sesbania aculeata)	3.5	0.6	1.2
Sunhemp (Crotalaria juncea)	2.3	0.5	1.8
Siris (Albizzia lebbek)	2.89	0.65	2.59
Asuro (Adhtoda vasica)	4.30	0.88	4.49
Tetepati (Artemesia vulgaris)	2.40	0.41	4.90
Khirra (Holarrhwa antidysenterica)	2.7	0.79	2.89
Taramandal	4.96	0.87	5.23
Ankhetare	2.77	0.49	2.40
Banmara (Eupatorium adenophorum)	2.36	0.67	3.98
Water hyacinth (Echhorinia sp.)	1.68	1.60	9.96
Azolla (Azolla pinnata)	4.0-4.5	1.60	1.0

Nutritional composition of some concentrate organic manures

Source	Nitrogen (N%)	Phosphorus (P_2O_5%)	Potash (K_2O%)
Mustard cake	5.2	1.8	1.2
Sesame cake	6.2	2.1	1.3
Castor cake	4.4	1.8	1.4
Japu cake	2.6	1.2	1.1
Groundnut cake	7.3	1.5	1.3
Linseed cake	5.5	1.4	1.3
Neem cake	5.0	1.1	1.5
Mahuwa cake	2.5	0.8	1.8
Night soil	10.0	0.8	0.4
Fresh night soils	1.3	1.1	0.35
City compost and sludge	0.65	0.55	0.75
City canal and sewage	0.92	1.2	4.9

Nutritional composition of some inorganic manures

Nitrogenous fertilizer

a) Sodium nitrate	16% Nitrogen
b) Calcium nitrate	15.5% Nitrogen

Ammonium sulfate

a) Ammonium sulfate	21% Nitrogen
b) Ammonium phosphate	20% Nitrogen and 20% Phosphorus
c) Ammonium chloride	24 - 26% Nitrogen
d) Anhydrous ammonia	82% Nitrogen
e) Ammonia solution	20 - 25% Nitrogen

Nitrate and ammonium fertilizer

a) Ammonium nitrate	33 - 34% Nitrogen
b) Calcium ammonium nitrate	20% Nitrogen
c) Ammonium sulfate nitrate	26% Nitrogen

Amide fertilizers and show release:

a) Urea	46% Nitrogen
b) Calcium cyanamide	21% Nitrogen
c) SCU = Sulfur coated urea	33% Nitrogen
d) IBDU = Isbutylidine diurea	34% Nitrogen

Phosphatic fertilizers

Water soluble phosphorus fertilizers:

a) Single super phosphate	16% Phosphorus
b) Double super phosphate	32% Phosphorus
c) Triple super phosphate	48% Phosphorus

Citric acid soluble phosphorus fertilizers:

a) Basic slag	14 - 18% Phosphorus
b) Dicalcium phosphate	34 - 39% Phosphorus
c) Rhenania phosphate	23 - 26% Phosphorus

Phosphorus fertilizers not soluble in water or citric acid or containing insoluble phosphoric acid or tricalcium phosphates.

a) Rock phosphate	20 - 40% Phosphorus
b) Raw bone meal	20 - 25% Phosphorus
c) Steamed bone meal	22% Phosphorus

Potassic fertilizers:

a) Muriate of potash	60% Potash
b) Potassium sulfate	48% Potash
c) Potassium nitrate	44% Potash

Compound and complex fertilizers:

20-20-0, 20-0-10, 18-22-0, 15-15-15 (Nitrogen-Phosphorus and Potash).

Kishanmal - 7-10-7 (7% Nitrogen, 10% Phosphorus, 7% Potassium).

Nutritional composition of important micronutrients

Zinc sulfate	22 - 35% Zinc
Ferrous sulfate	20% Ferrous
Copper sulfate	25 - 35% Copper
Manganese sulfate	23% Manganese
Borax or sodium borate	10% Boron
Sodium molybdate	37 - 39% Molybdenum

For micronutrients that can be applied to crops in general

Micronutrients Compounds generally used. Safe range of application (kg/ha)

		Soil	Spray
Iron	Iron sulfate	16-56.0	5.6-7.8
Zinc	Zinc sulfate	5.0-56.0	2.3-22.4
Manganese	Menganese sulfate	16-33.0	4.5-9.0
Copper	Copper sulfate	2.3-56	0.56
Boron	Borax	5.6-33.6	-
Molybdenum	Sodium or Ammonium molybdate	0.07-2.3	0.028-0.035

UNIT 13
WATER MANAGEMENT

Water management is the practice which includes the integrated process of intake, conveyance, regulation, measurement, distribution, application and use of irrigation water to farms, the proper amount securing maximum rice yield.

Basis of considerations for a suitable irrigation system:

a) The consumptive water use by rice plants at different growth stages

b) Soil texture and its percolation and seepage rates

c) Seasonal distribution of rainfall

d) Topography of fields.

e) Availability of irrigation water

Methods of irrigation:

Flood water requirement for rice is 1000 - 1500 mm. There are three methods of irrigation:

- Continuous flow irrigation
- Rotational irrigation (every day, week etc.)
- Intermittent irrigation (the field alternately flooded and drained)

a) Continuous flow irrigation for rice:

- it is expensive but useful at high temperature areas where temperature of water is lower than the air temperature
- needs less supervision
- is helpful for weed control

b) Rotational irrigation:

- it is quite popular in canal irrigated areas and is less expensive
- is irrigated every 10 - 15 days
- 5 cm standing water is required in field
- seepage and percolation losses are comparatively less.

c) Intermittent irrigation:

- frequency of irrigation depends on the sources available and also on rainfall pattern
- saves irrigation water
- reduces the development of toxic materials in the field
- drainage problem is minimum

Water need according to season and soil types:

- usually 4-5 mm of water per day is needed for the rice plant during the wet season.
- in dry season, seepage, percolation and evapotranspiration is very high: 6 - 8 mm per day.
- seepage is affected by soil texture, water table and hard pan developed in the soil.

- seepage loss is around 1 - 2 mm per day but may be more in sandy soils.

Water management schedules

Water management requirements at different growth stages of rice are:

At transplanting:
Shallow sheet of water (2-3 cm) in the puddled field.

After transplanting:
No water application for 3 days and after that establish and maintain a level of 5 cm of water.

- Stop watering for 5 days in between for weeding and top dressing of fertilizer.

Tillering stage:
Maintain a shallow depth (2-3 cm). Drain the field for 5 - 7 days at maximum tillering stage if there is assured supply of water.

Panicle formation stage:
Increase the level of water from 5 to 10 cm.

Flowering:
Maintain a level of 10 cm of water.

Ripening:
Reduce the water depth of 10 cm gradually and drain the field 10 - 15 days before harvesting.

Growth stages of rice during which irrigation is most important:

Seedling stage: for initial root growth and development.

Tillering stage: for maximum tillering.

Panicle initiation to flowering stage: for uniform and better growth of panicles.

Milkdough stage: for proper grain filling.

Rice is most sensitive to water from twenty days before heading to ten days after heading.

Problems due to unmanaged irrigation systems and water quality:

- water logged soils due to continuous seepage and percolation.
- rise of ground water table.
- formation of toxit and deficient nutrients because of organic acids in poorly drained soils.
- deposition of unfertile sands and silts as in Seti project Kunarphant (Pokhara) due to sandy and silty water quality.

Water losses

Water management becomes effective only if water losses are minimized.

The components of water losses are:

- Farm waste: Ex. run off from over irrigation.
- Seepage and overflow from canals and farm ditches.

Saving irrigation water could be done by maximizing the effective rainfall.

Maximizing effective rainfall may be done through

a) Improvement and proper maintenance of farm dikes (bonds)

b) Application of shallow depth of irrigation water.

c) Practice of intermittent application of irrigation water.

UNIT 14
INSECT PESTS OF NEPAL

U14.01 RICE BUG (LEPTOCORISA VARICORNIS L. ACUTA)

Nepali name: Patero

The rice bug is a major pest of rice in Nepal. It is prevalent throughout the country. However, its occurance in epidemic form depends on the cropping pattern and climatic factors of the particular place.

Identification: The adult insect is long, slender and brownish green. A newly hatched nymph (immature form) is wingless, green and later becomes brownish. The presence of both adult and nymph in the rice fields can be detected by the foul odor which they emit.

Nature of Damage: Both nymphs and adults suck the milky juice from developing grains of rice by inserting their probocis at a point where the glumes meet. Feeding during the milk stage results in empty grains. Feeding during the dough stage results in cracked or broken grains. Their feeding also produces brown lesions on the grains. The attack remains until the rice grain hardens. In the case of severe infestation it may cause complete loss.

Alternate Host: A number of wild grasses and weeds around/inside the rice fields harbour this pest until the rice crop is in the milk stage.

Life History: The longevity of the adults is 45-60 days in field conditions. The adults are active during the early morning and in the evening, while during the day the insects hide in the shade of the basal parts of the plants. The female lays its eggs in 1 to 3 rows along the midrib of the upper surface of the leaf blade. The freshly laid eggs are creamy white but become dark brown before hatching. A single female can lay about 300 eggs in batches of 10 to 20 eggs. The insect overwinters (from December to March) and passes the summer (April - June) in the adult stage as scattered individuals on alternate hosts like grasses and weeds. In single cropping areas the insect usually has four overlapping generations, but in areas where temperatures are optimum and rice is grown all the year, the bugs remain active throughout the year without a distinct diapause (a spontaneous state of dormancy or rest); in such areas there is heavy infestation. The life cycle detail is presented in Figure 24. The adult survives for 30 - 35 days.

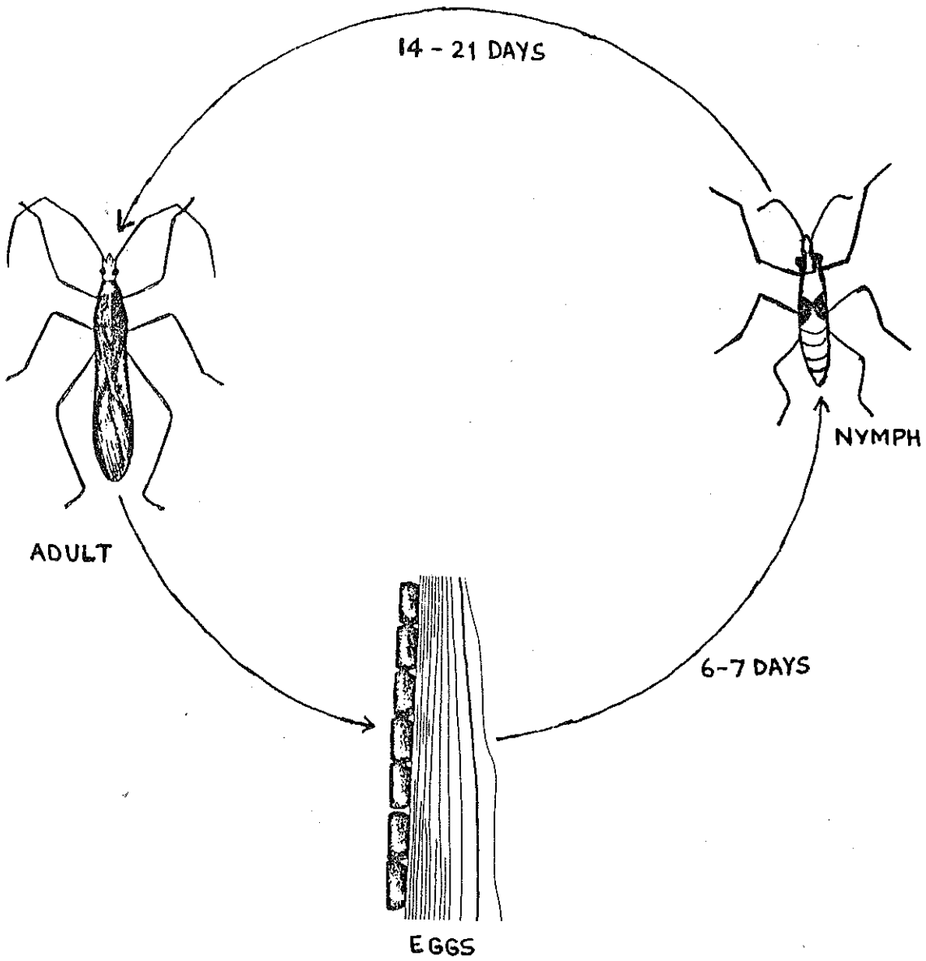


FIGURE 24: Life cycle of Rice Bug

Control:

1. Practice clean culture and remove weed hosts frequently from the rice fields. This prevents the infestation and breeding of rice bugs, especially during the growing season.

2. Destroy the eggs seen during weeding and the regular inspection of the rice fields.

3. Catch the adults and nymphs with nets and kill them. The net (Figure 25) can be constructed easily.

4. Smoking the infested field can give promising results against this pest.

5. The phototropic nature of the insect can be exploited with light traps as a method of control. During the night, in the center of the infested field hang an ordinary lantern (Figure 26) or petromax or electricity bulb over (20 cm above) a basin containing a mixture of water and kerosene (sufficient to form a distinct layer of kerosene above the water). The bugs which are attracted to the light-trap will fall into the basin and die.

6. The population of this insect pest is at its peak in September and reduces in November. Thus, use of cultivars which mature either before September or after November can either escape or reduce pest damage. However, late maturing varieties create a problem for winter crop planting (delay in wheat planting). Hence, a suitable rice based cropping pattern should be searched out.

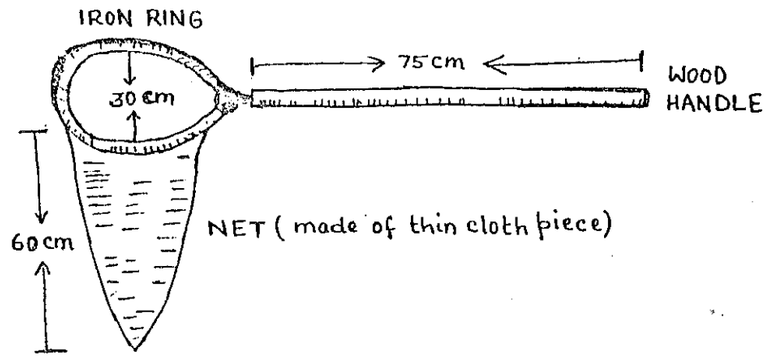


FIGURE 25: Insect catching net

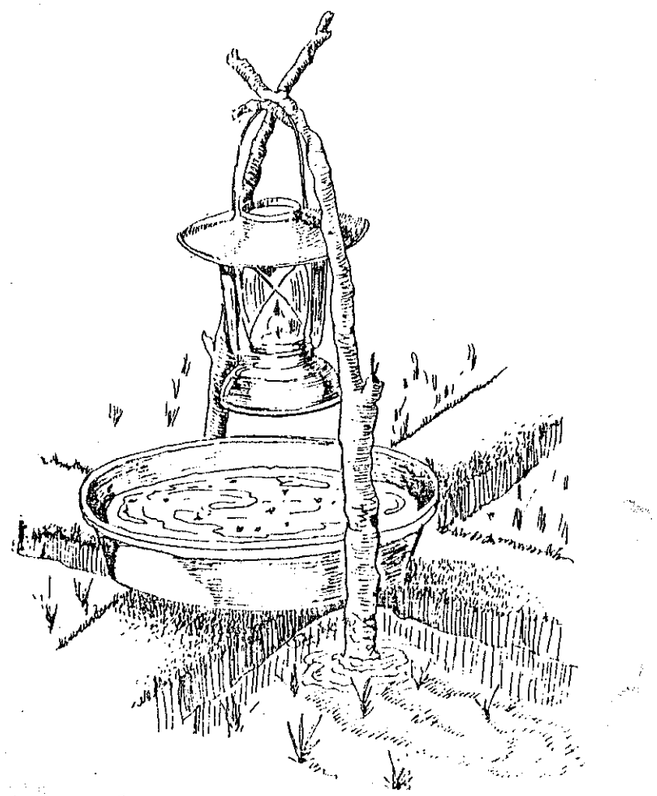


FIGURE 26: Light trap using lantern

7. Adjusting the planting date can also escape or minimize pest damage. Thus, a variety with a wide range of planting dates should be selected.

8. Tiger beetles and spiders are natural enemies of the rice bug. Both feed on rice bugs (adult and nymph). If their population is high enough in the rice fields delay the insecticidal use.

9. If the number of rice bugs is high enough (8 or more/m^2) chemical control is necessary. The rice bug can be effectively controlled by spraying with any one of the following concentrated insecticid spray solutions:

   Sevin 50WP 0.1% a.i.
   or
   Folithion 100 EC 0.05% a.i.
   or
   Metacid 50 EC 0.05% a.i.
   or
   Thiodan 35 EC 0.07% a.i.
   or
   Nicotine sulphate 0.2% a.i.

A new formulation containing 0.01% nicotine sulphate and 1.25 sesame oil as synergist is also very effective against the rice bug.

Repeat spraying after 7 days if infestation persists. If the infested fields are weedy, insecticidal spraying will have minimal effect on rice bugs.

The time of spraying chemicals depends on the fertilization period in the rice which usually takes place between 8 to 11 a.m. in the terai and between 11 a.m. to 3 p.m. in Kathmandu valley.

The glumes of the rice are open at that time. If spraying is done at that time the insecticide may go inside the sap and cause sterility. Thus, late afternoon (after 3 p.m.) should be prefered for spraying.

U14.02 RICE STEM BORER

Nepali name: Dhan Ko Gaboro

In Nepal four species of borers, namely, yellow borer (Tryporyza incertulas), white borer (T. innotata), pink borer (Sesamia inferens) and striped borer (Chilo suppressalis) are known to attack rice plants. However, yellow and pink borers are of economic importance.

These insect pests are distributed throughout the country. Their occurance in epidemic form has been reported from Tarhara and Dhading district of Nepal.

Identification: The common names of stem borers are based on the colour of their larvae. The identification details are given in Table 17 and Figures 27 and 28.

Nature of Damage: Only the larvae are destructive. They bore and feed inside the rice stem. It can not be seen unless the stem is split open. While feeding inside the stem, the larva cuts off the growing part of the plant from the base causing the plant or tiller to die. This condition is known as "dead heart" and it occurs when plants are attacked during the young stage. The borer attack during the flowering stage results in whitish panicles and are called "white heads".

Alternate Host: No alternate hosts have been reported for yellow and white borers. They are monophagous to rice. Pink borer can feed on maize, wheat, sugarcane, barley, sorghum, millet, oat and other grasses while striped borer can attack millet, maize and many other grasses.

Life History: All rice stem borers lay eggs in masses usually containing 50 to 80 eggs. A single female is capable of laying 100 to 200 eggs. The newly hatched larvae start boring and then feeding inside the stem. The first generation larvae require 1.5 hours from hatching to enter the leaf sheath but a longer period is required by the second generation. The moth emerges through an exit hole prepared by the larvae. The adult female moths start laying eggs one week after their emergence. Depending on the environmental conditions. The borers can have 1 to 5 generations per year. The life cycle detail is shown in Figure 29.

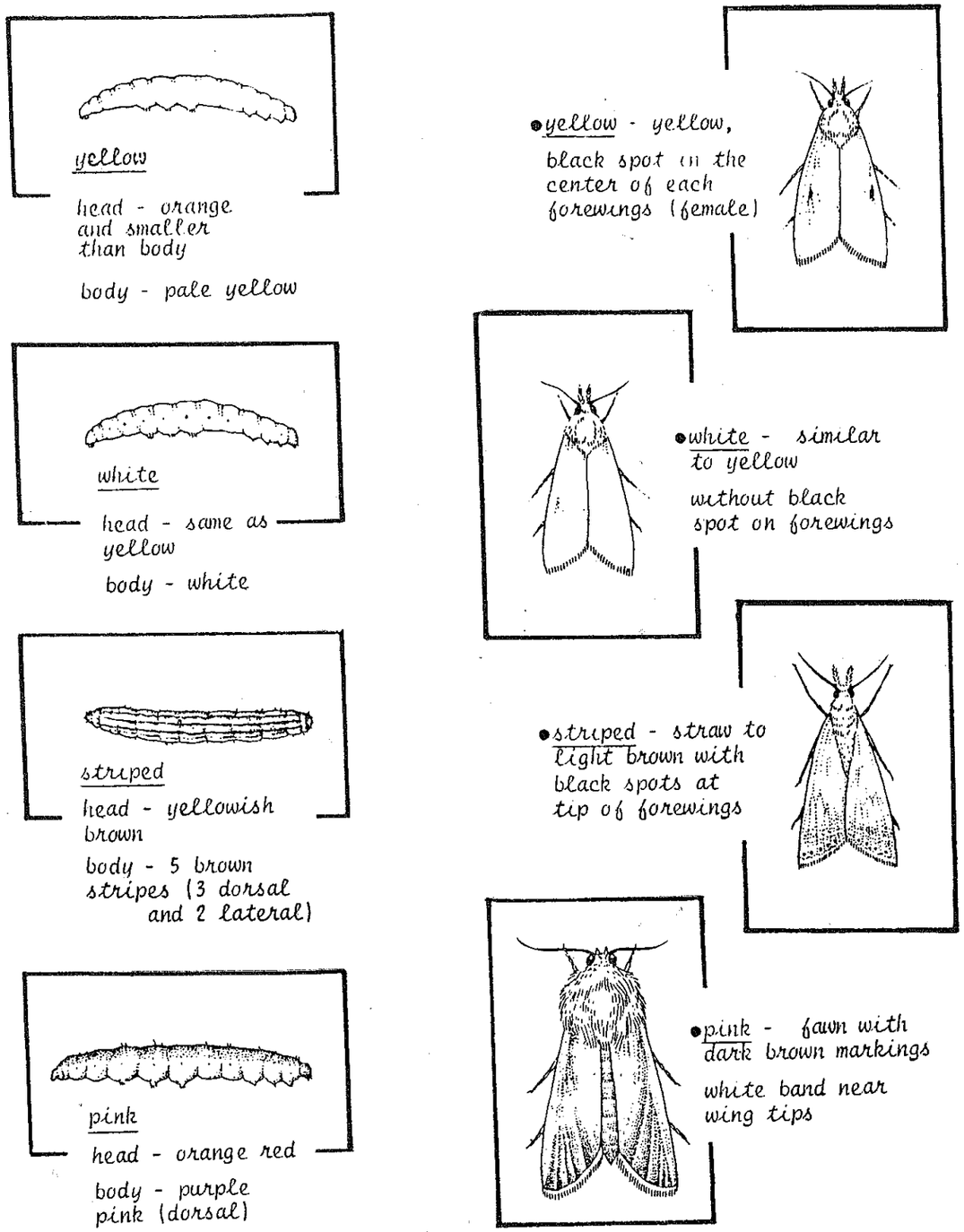


FIGURE 27: Larvae and adults of Stem Borer

Species	Moth	Egg Mass	Larva
Yellow borer	Straw-coloured, pointed head, fore wings of the female have black spot in the centre.	Covered with soft silky brownish hair.	Yellowish with velvety surface texture and a brown head capsule.
White borer	White, pink abdominal tip.	Covered with soft greyish hairs.	Creamy white, distinct dark stripe on the back.
Pink borer	Brown, white band along the tip of each wing.	Eggs laid in rows in between the leaf sheath and stem.	Pink, dark headed, two distinct posterior appendages.
Striped borer	Dirty brown, fore wings have a row of small spots along the tip.	Scale like.	Five-longitudinal dark stripes, light brown head.

TABLE 17: Identification of Rice Stem Borers

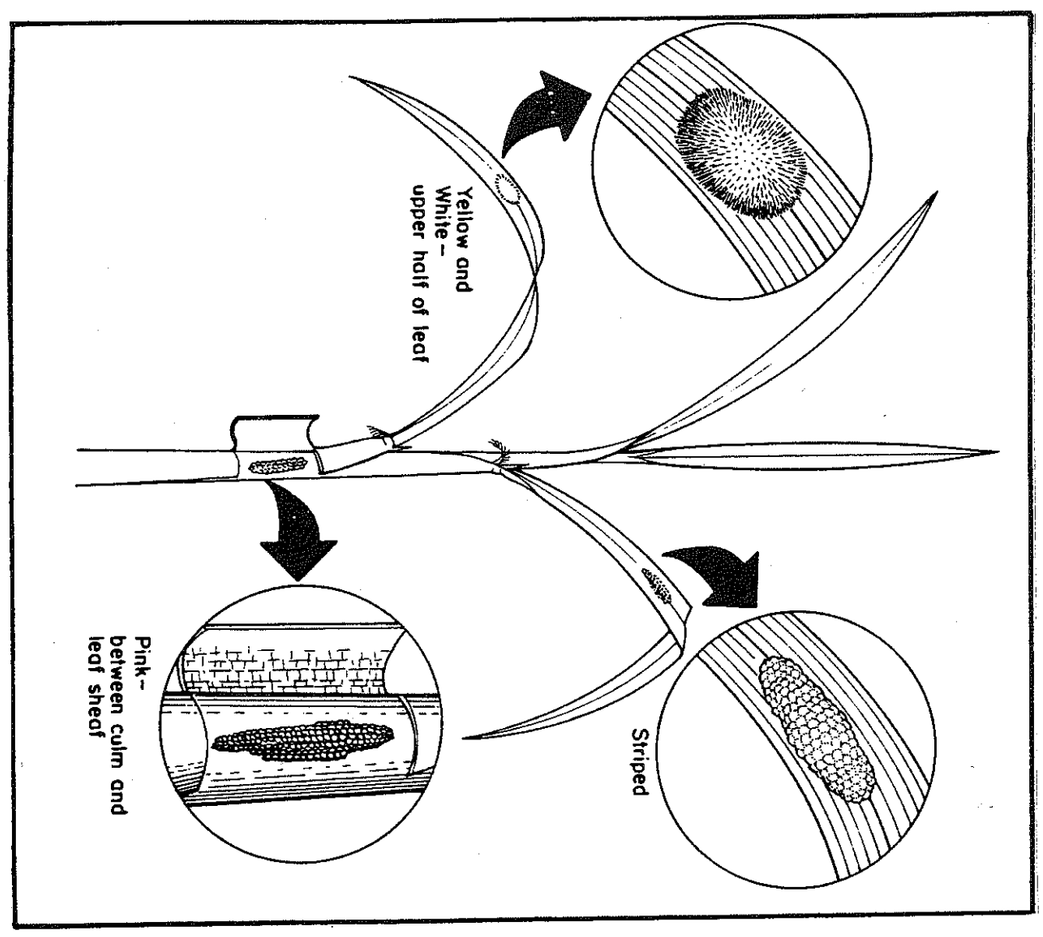


FIGURE 28: Egg mass location of Stem Borers

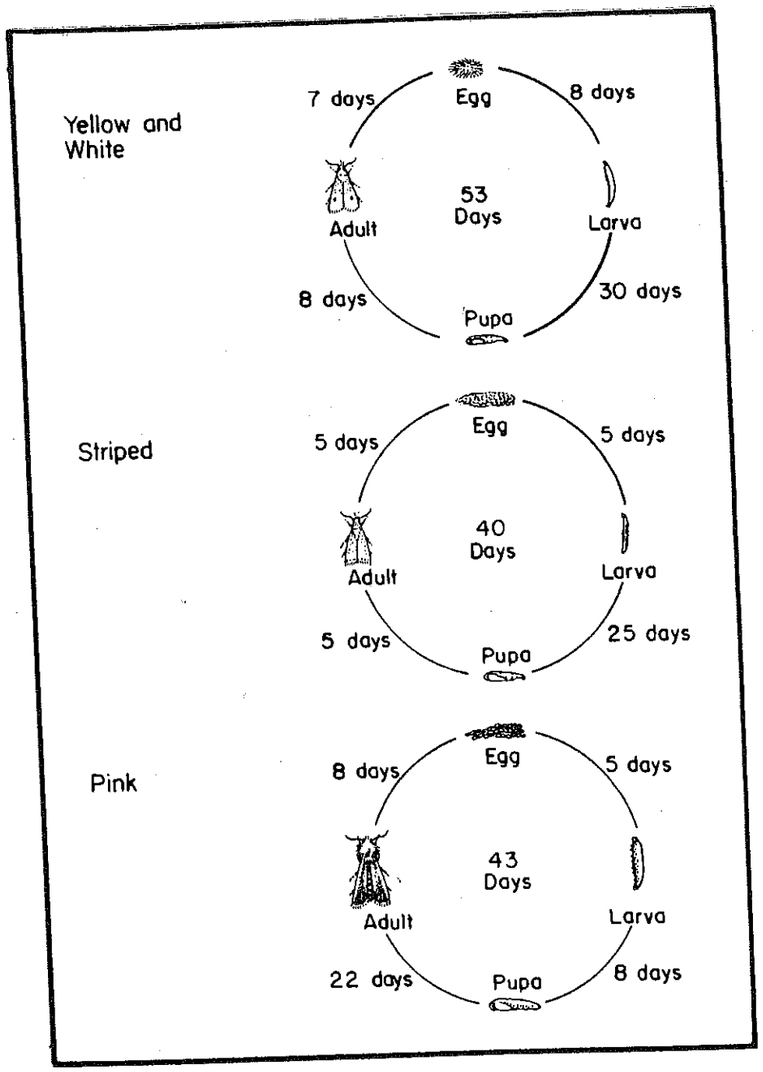


FIGURE 29: Life cycles of Stem Borers

Control:

1. Since yellow and white borers lay eggs near the tip of the leaf blade, clipping (1 to 2 cm) the seedlings before transplanting greatly reduces the carry-over of eggs from seed bed to the transplanted fields.

2. A large number of larvae and pupae remain in the stubble after harvest and serve as an important source of infestation for succeeding crops. Thus, to minimize infestation on the succeeding crops the following practices should be followed:

   2.1 Burn the dried stubble from the previous crop after harvest.

   2.2 If water is available completely submerge the rice stubble for at least 5 days followed by harrowing.

   2.3 Plough under stubble when it is uprooted.

   2.4 Harvest the stems close to the ground to remove the larvae from the stubble tops which can be destroyed.

3. Remove grassy weed and rice plants that have come up in the field from the seed left from the previous harvest. These will deprive the borers of intermediate hosts for their survival.

4. Depending on the local conditions, the time of planting the first crop may be altered to reduce borer infestation by minimizing larval feeding in the stems at panicle initiation.

5. The use of an earlier maturing rice variety will impair the population buildup because harvest will be sooner and will disrupt the life cycle of the rice borer.

6. Where two crops are grown in succession, all farmers in a particular area must synchronize their first plantings to allow a rice free period between crops.

7. To delay borer build-up avoid placing the seed bed nursery for the second crop concurrently with the first crop.

8. Follow the rice bug control number 2 and 5.

9. Rice varieties, namely, IR 38, TNAU 1756, W 1263, and IR 20, are resistant against the borer attacks. Depending on the local conditions, any one or two of these varieties should be planted in the problem area.

10. The occurance of egg parasites (Trichogromma spp., minute wasps) of the rice borer have been also reported in Nepal. If these parasites are seen in the rice fields do not disturb them.

11. Since the larvae feed inside the stem, systemic insecticides (translocated throughout the plant system) or those which are absorbed by the plant roots are most effective against them. However, these insecticides are more expensive than foliar or contact insecticides. Recommended granular insecticides are Furandon 3 G, Diazinon 10 G, Thimet 10 G, Lindane 10 G and Sevidol 8 G. Anyone of these insecticides can be used 1 to 2 kg a.i./ha. First application should be made at the rate of 1 kg a.i./ha on the basis of the inspection of rice fields from 10 to 40 days after transplanting and only when an average of 10% dead hearts occur. Again inspect the rice fields for 41 to 70 days after transplanting, if 5% dead hearts occur, application with any of these insecticides at the rate of 2 kg

a.i./ha should be made. Between booting and panicle initiation, if abundance warrants, granular treatment is needed at the rate of 2 kg a.i./ha for lowland rice. When applying granular insecticides, fill the rice fields with 5 - 8 cm of water, close all outlets, and repair the dikes. Prevent the outflow of water for 4 days while the insecticide is active. Rubber gloves should be used for broadcasting granular insecticides.

For upland rice as well as when the granular form of earlier mentioned insecticides are not available, contact or foliar insecticides can also be used. However, the degree of control of rice borers with these insecticides will depend on the time and number of foliar applications. Foliar insecticides, recommended (with same rates) for the control of the rice bug, can also be used against the rice borers. If egg masses and moths are seen in the nursery bed, the first spraying should be done right away. The second spraying should be carried out after the transplanting and only when 10% dead hearts or one egg mass per eight hills occurs. A third spraying is continued if the percentage of dead hearts is not minimized.

U14.03 LEAF AND PLANTHOPPER

Nepali name: Phadke Kira

Four species of hoppers, namely: green leafhopper (Nephotettix appicalis), brown planthopper (Nilaparavata lugens), white backed planthopper (Sogatella furcifera), and zigzag leafhopper (Inazuma dorsalis) are recorded in Nepal.

These insect pests are distributed throughout the country. In the year 1972, green leafhopper occured in epidemic form in Palpa district, where it caused 60% loss of crop. Likewise, in the year 1982 white backed planthopper occured in epidemic form in Kathmandu and Bhaktapur districts. However, the control campaign carried out by the Entomology Division, Khumaltar, controlled this pest completely.

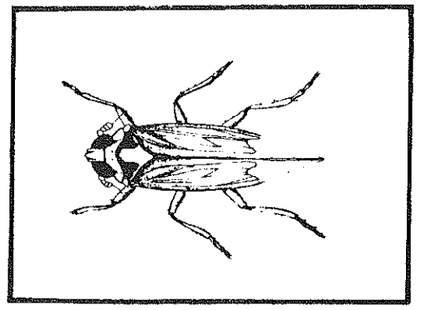
Identification: The hoppers are very small (4 - 5 mm long) and found in groups. They make frequent jumping if disturbed. Their names are derived from the colour and distinctive markings of the species (Table 18 and Figure 30).

Species	Adult
Green leafhoppers	Greenish, with black spots on the wings (mostly in males), sub marginal black band in vertex present
Brown planthopper	Light or dark brown
White backed planthopper	White pentagon shape pattern on dorsal thorax
Zigzag leafhopper	Brownish zigzagged pattern on the wings

TABLE 18: Characteristics of leaf and planthoppers

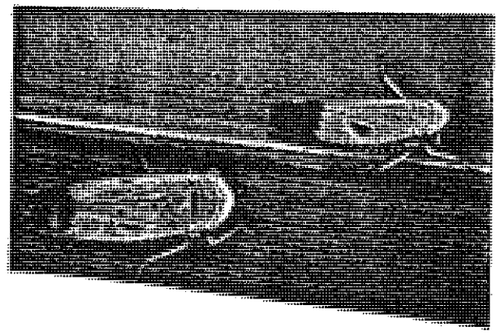
Brown Planthopper

light to dark brown
winged and non-winged adult



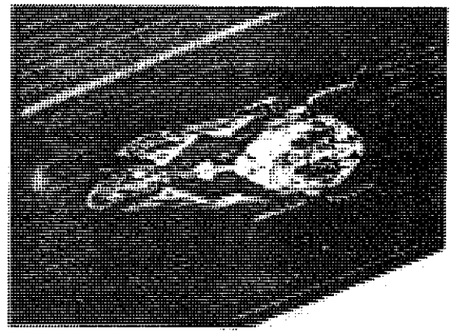
White-backed Planthopper

long-narrow face
black body
yellow antennae and thorax
forewings hyaline with dark veins and black dot



Green Leafhopper

bright green
black markings



Zigzag Leafhopper

zigzag pattern

FIGURE 30: Leaf- and Planthoppers of Nepal

Nature of Damage: the leafhoppers feed on the leaves and the upper part of the plants, whereas planthoppers confine themselves to the basal parts. Both nymph and adult directly damage the rice plants by sucking the plant sap. A severe attack of these pests causes complete drying of the rice plant and is called hopper burn. These pests (except the white backed planthopper) also transmit serious virus diseases in rice.

Alternate Host: Millets, maize, sugarcane, wheat and other grasses and weeds.

Life History (Fig. 31): All leaf and planthoppers species have almost identical life cycle patterns. The females lacerate the midrib of the leaf blade or leaf sheath and lay their eggs in rows. The eggs are banana shaped. When freshly laid they are whitish but later become darker. The adults survive for about 3 weeks. Under favourable conditions, the hoppers can have 6 or more generations per year. The life cycle detail is presented in Figure 31.

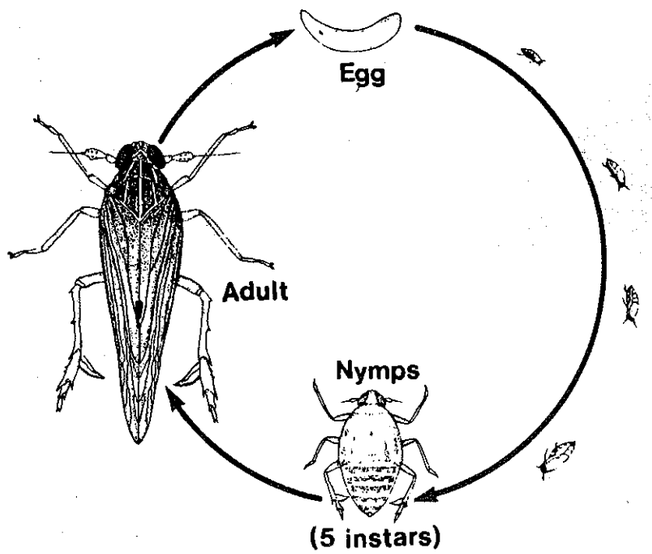


FIGURE 31: Life cycle of Leave and Planthoppers

Control:

1. Remove weeds and virus infested plants. This will reduce the incidence and spread of virus diseases.

2. A higher rate of nitrogen fertilizer applied in the rice fields results in a high rate of reproduction of leaf and planthoppers (by making the plants more succulent and attractive). Thus, nitrogen fertilizer should be used at a moderate rate to prevent severe infestation.

3. Catch adults by light traps (refer to the rice bug).

4. Use resistant varieties like Ratuneenat, Babawee, Hondrawala, Pokhareli masino, IR 26 and IR 30 in problem area.

5. Many parasites and predators of brown and white backed planthoppers are known to occur in the rice fields. Thus, these natural enemies should be identified and protected to counteract hopper problems.

6. Metasystox (systemic insecticide) @ 0.025% can be used against the hoppers, as foliar spray. For additional insecticidal refer to the rice bug and stem borers (same rate can be used). Insecticidal use is advisable only when one mature nymph per tiller is seen in the rice fields.

U14.04 RICE GALL MIDGE (PACHYDIPLOSIS ORYZAE)

Nepali name: Dhungre Kira

This pest is prevalent in Makwanpur, Bara and Parsa districts of Nepal.

Identification: The adult fly is about the size of a mosquito. The female has a bright red stout abdomen, but the male is pale brown. The larva (maggot) is 1 mm long at hatching. It is translucent and has a pointed anterior end. The full grown larva is 3 mm long and pale red in colour.

Nature of Damage: Adults feed on dew drops. The larvae feed on the growing point of the tillers. Their feeding stimulates the tillers to grow into a tubular gall which resembles an onion leaf. This damage is known by the name silver shoot or onion shoot. Damaged tillers do not produce panicles. The gall midge larva can not survive beyond the vegetative stage.

Alternate Host: Many grasses and weeds present inside/around the rice fields.

Life History: The adult female lays its eggs (elongate and tubular shape) singly or in groups of three to four on the undersides of the leaves or on the leaf sheaths of rice seedlings. The egg colour varies from white or pink to red but all eggs become shiny amber before hatching. Soon after hatching, the larva moves down between the leaf sheath and stem until it reaches the growing point of the tiller. The larva pupates at the base of the gall. The females survive for about 3 to 4 days. See figure 32 for its life cycle.

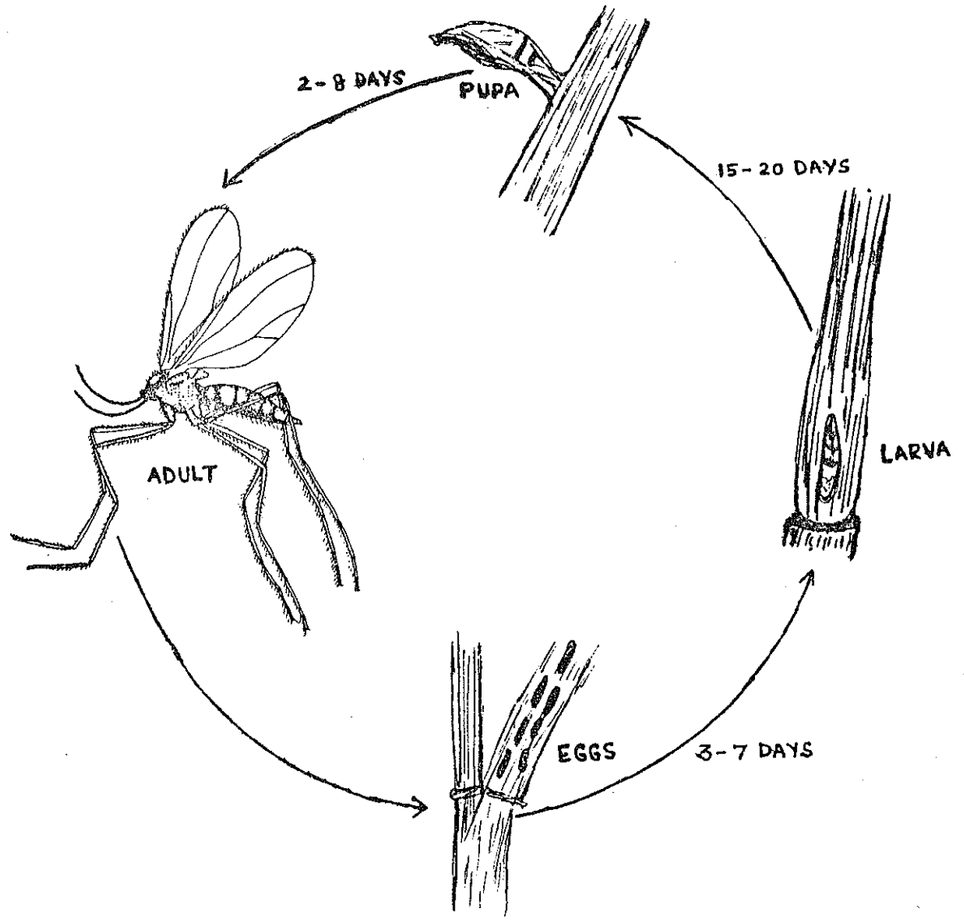


FIGURE 32: Life cycle of Gall Midge

Control:

1. Remove grasses from the fields to prevent the initial build-up of gall midge population, because the midge develops 1 or 2 generations on the host grasses at the beginning of the wet season just before the rice is planted.

2. A crop planted at the beginning of the wet season may escape severe infestation because the crop will probably grow beyond the vegetative stage and the gall midge cannot survive beyond this stage.

3. Remove galls and stubble and burn them.

4. Use light trap (refer to the rice bug).

5. IR 40 may be used.

6. Dipping seedlings prior to transplanting for 24 hours in Furadon 75 WP or Diazinon 20 EC suspension dilu at 30 ppm can eradicate gall midge larvae.

7. Use of Thimet 10G @ 1.5 kg a.i./ha or Furadon 3G @ 1.0 kg a.i./ha 2 to 4 weeks after transplanting can give effective control of gall midge. Generally, insecticidal use is necessary only when 5% gall is seen in the rice fields. In the absence of these granular insecticides, foliar spray of Malathion 50 EC @ 0.1% or Dimecron 100 EC @ 0.02% or Fenitrothion 100 EC @ 0.05% or Thiodan 35 @ 0.07% can be used 4 to 5 times at an interval of 10 days, after transplanting, while in the nursery bed, 2 sprayings should be done at 10 days interval.

U14.05 RICE LEAFFOLDER (CNAPHALOCROSIS CEDINALIS)

Nepali name: Pat Beruwa

This pest is prevalent throughout the country. However in the year 1977 it occured in epidemic form in Dhanusa, Taleshwar, Sarlahi, Parsa and Bara districts.

Identification: The adult moth is brownish grey with dark wavy lines on the wings. The full grown larva is yellowish green with a dark brown head and is found in folded leaves.

Nature of Damage: The damage is caused by the larvae which fold the leaf blades into tubular structures and feed on the green leaf tissues within these structures. Larvae feeding results in white transparent streaks running parallel to the midrib. Infestation at booting and flowering is the most destructive while infestation after grain formation is much less destructive.

Alternate Host: This pest is polyphagous in nature. Various grasses, sedges, maize, sorghum, millet and wheat have been recorded as alternate hosts.

Life History: The adult female lays eggs either singly or in rows along the midrib on either surface of the leaf blade. The eggs are translucent, yellowish, white, flat and oval shaped. The freshly hatched larva has a white translucent body and light brown head. The full grown larva undergoes population inside the leaf roll. The newly formed pupa is bright yellow but becomes brown near emergence. The leaf folder is active from May to October. During this period it completes four to five generations (see Figure 33 for life cycle).

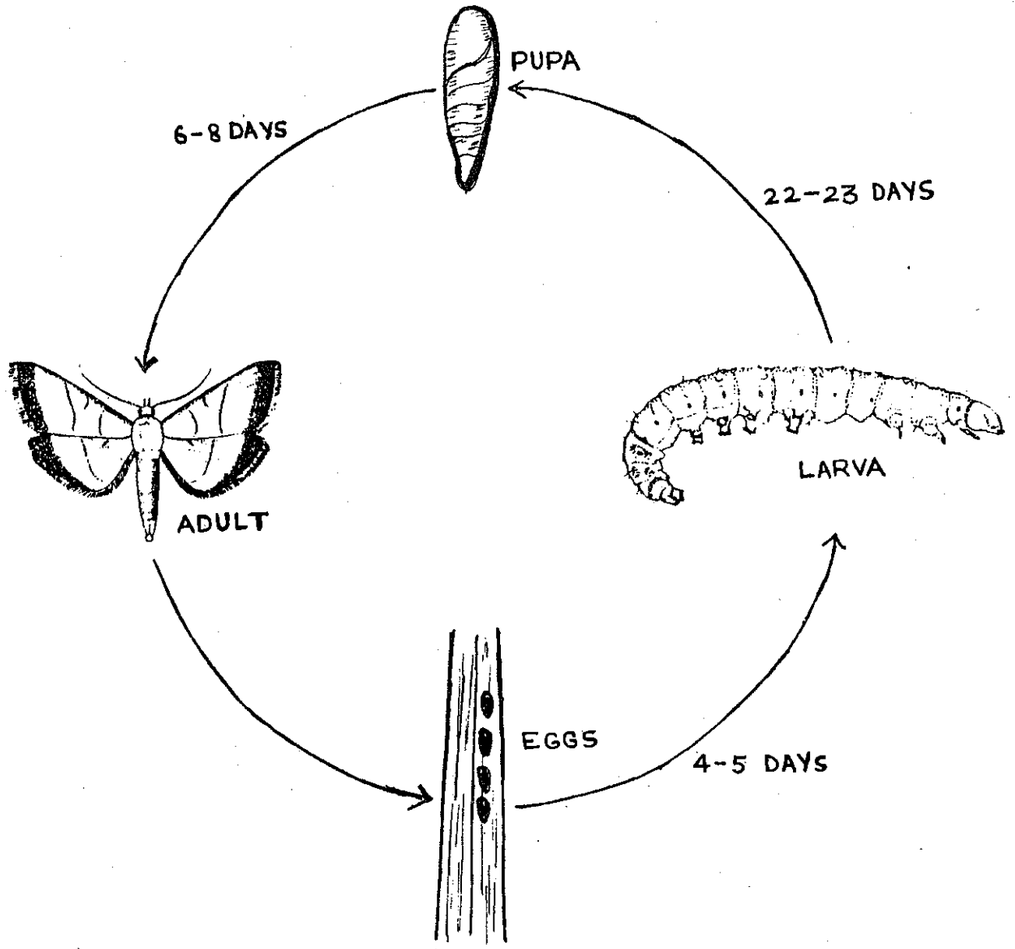


FIGURE 33: Life cycle of Rice Leaffolder

Control:

1. Remove alternate host from the rice fields.

2. Destroy eggs and larvae seen during the inspection of the rice fields.

3. For insecticidal use, refer to the rice bug.

U14.06 RICE HISPA (HISPA ARMIGERA, DICLADISPA ARMIGERA)

Nepali name: Dhanko Kandedar Kira (Dhanko Pat Khane Kira)

This is the serious pest of young seedlings, especially during late transplanting in the water logging condition. Its occurance in epidemic form has been reported from many parts of Nepal namely, Bara, Parsa, Godwari, Thankot, Jhapa and Janakpur.

Identification: The adult beetle (about 5.5 mm long) is shiny blue black with a spiny body. The larva (grub) is small (3.3 mm) and white in colour.

Nature of damage: Both the adults and grubs feed on the chlorophyll of the leaf blade and their feeding results in white streaks. In severe infestation the leaves turn whitish and membranous and finally dry off (Figure 34).

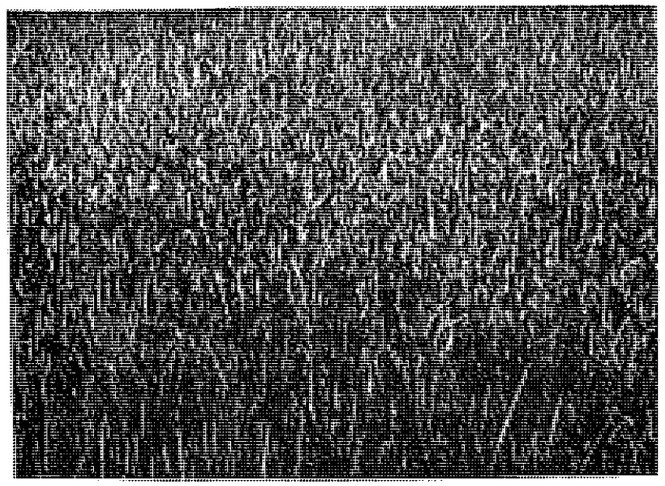


FIGURE 34: Hispa damage; note white streaks

Alternate Host: Sugarcane and grasses. Grasses play a major role in the initial multiplication of this pest at the beginning of the cron season and also in their continued survival.

Life History: The adult female lays its eggs (shaped like sesamum seeds) near the tip of the leaf blade and inserted inside tissues. The larva mines into the leaf blade between the epidermal membranes and pupates. The emerging beetles cut their way out of the leaf and become external feeders. The adult females and males can survive up to an average of 20 and 14 days, respectively. The life cycle detail is presented in Figure 35.

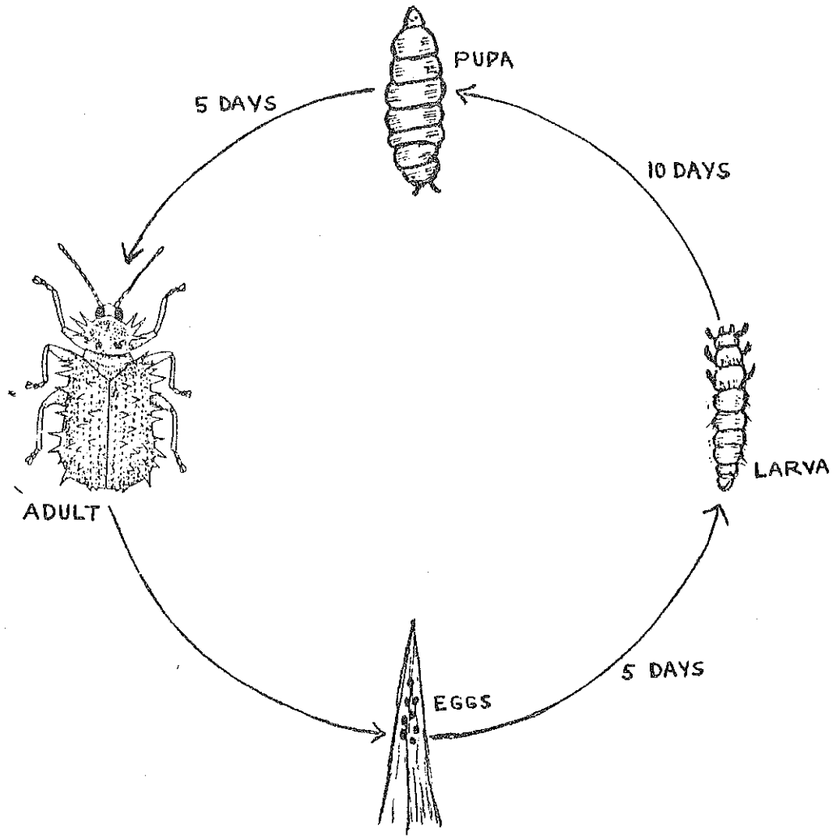


FIGURE 35: Life cycle of Rice Hispa

Control:

1. Destroy weed and grass hosts of hispa from fields and bunds during and after the crop season.

2. Catch the adults by nets in the early morning hours.

3. Clip leaf tips of seedlings and bury or burn them to destroy eggs and larvae.

4. Adults prefer tender seedlings in nurseries and rice crops 20 to 60 days after transplanting for feeding and oviposition. Thus raising crops very early in the season escapes or suffers only negligible damage.

5. Avoid using excess nitrogen fertilizer, because top dressing a rice crop with nitrogen during hispa abundance produces greater damage.

6. In problem areas, farmers usually use seedlings from dry seed beds. And also during infestation farmers drain the fields and provide shelter for some predator birds. According to those farmers these practices are effective in minimizing the hispa damage.

7. Dip seedlings in 0.04% solution of Furaden 75 WP or Diazinon 25 EC and transplant.

8. Foliar application of Sumicidin 20 EC @ 0.02% is also very effective against the rice hispa. For alternative insecticides refer to the rice bug.

U14.07 RICE MEALY BUG (RIPERSIA ORYZAE)

Nepali name: Phusre Udus

This pest has been recorded from the Sarlahi, Rauthat Bara, Parsa and Kaski districts of Nepal. However, in the Sarlahi district, it is an epidemic pest.

Identification: The nymphs and the adult females are oblong reddish white and soft bodied with a distinct waxy or powdery coating. Their colonies are in an almost immobile position in between the leaf sheath and the stem (see Figure 36).

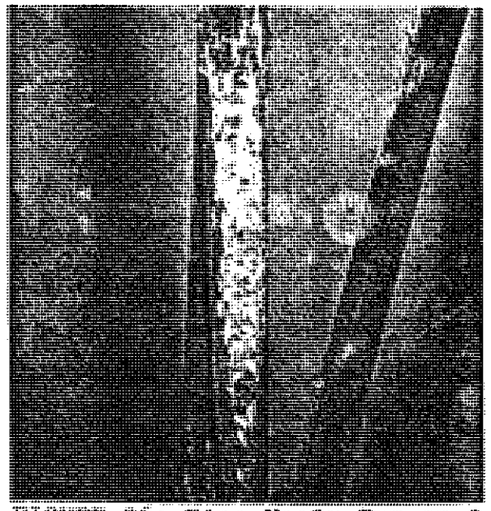


FIGURE 36: Rice Mealy Bug on leaf sheath

Nature of Damage: Both nymphs and adults feed by sucking the plant sap from the rice stem. Their feeding results in stunted growth and yellowish curled leaves. Severe infestation inhibit panicle emergence. The damage is seen in patches in the rice fields. The pest is more abundant in unirrigated areas than in frequently irrigated areas.

Alternate Host: Grasses

Life History: A single female can lay a total of 60 to 280 eggs and nymphs in about 5 days after which it dies.

Control:

1. Remove alternate host from the rice fields.

2. Irrigation helps to minimize the pest population.

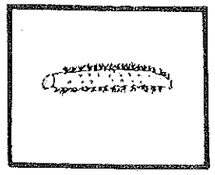
3. - For granular insecticides refer to rice stem borers.
   - Foliar applications of either Metasystox 25 EC @ 0.025% a.i or Dimecron 100 EC @ 0.1% a.i. is also effective against the rice mealy bug.

U14.08 RICE CASE WORM (NYMPHULA DEPUNCTALIS)

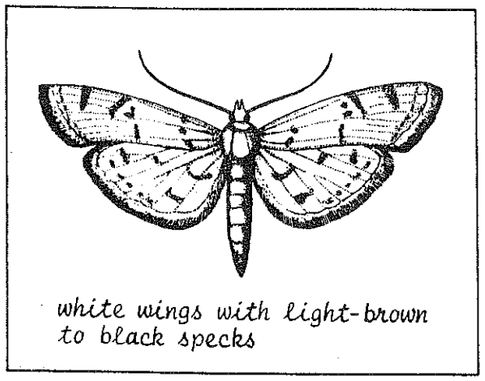
Nepali name: Dhanma Khol Banaune Kira

The occurance of this insect pest is sporadic mostly in eastern terai of Nepal.

Identification: The adult moth (6 mm long) is white with irregular light brown to black stripes on both wings. The larva is pale green and has a light brown head. A characteristic feature of the larva is the presence of rows of hair like gills on the body (see Figure 37).



larva in tubes
pale green, transparent skin
light brown head
rows of hair-like gills-body



white wings with light-brown to black specks

FIGURE 37: Larva and adult of Rice Case Worm

Nature of Damage: The damage is caused by the larvae feeding on the green tissues of leaves and by their cutting off the leaf tips for making leaf cases. Feeding damage can be distinguished from that of leaf folder in that the case worm leaves horizontal rows of green material as it feeds. This results in a ladder like appearance. Uneaten leaves can be seen floating on the water surface (see Figure 38).

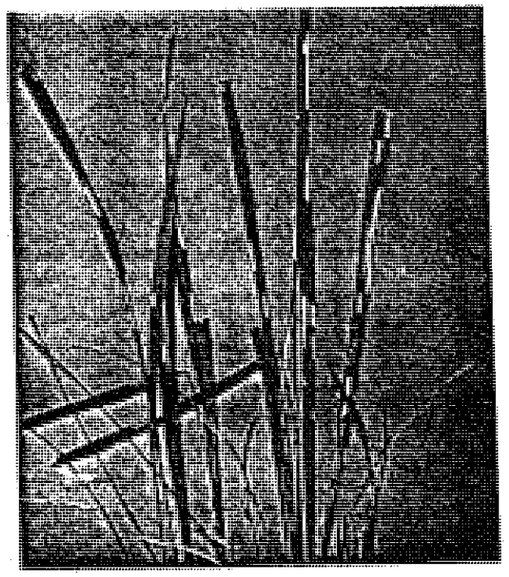


FIGURE 38: Damage to leaves by Rice Case Worm

Alternate Host: Grasses and Millets

Life History: A single female lays about 50 eggs during its life time. Eggs are laid in one or two adjacent rows on the lower surface of the leaves or on the leaf sheath near the water surface. Pupation takes place in a brownish tube of

leaves which is attached to the basal part of the tillers slightly above the water level. The adult moth usually lives for 4 to 8 days.

Control:

1. Remove grasses from the rice fields to minimize the population build-up of this pest.

2. Draining water from the infected rice fields reduces the damage to some extent.

3. This pest can be controlled by spraying with Sevin 50 WP @ 0.1% a.i., or Folithion (Sumithion) 100 EC @ 0.05% a.i.

U14.09 MOLE CRICKET (GRYLLOTALPA AFRICANA)

Nepali name: Biralo Kira or Twanti Kira

This insect pest occurs in the terai, inner terai and hilly regions of Nepal in every rice season.

Identification: This insect is brownish and very plump. Their front legs are modified for digging. The fore tibia are modified into spade like structures resembling the feet of a mole (see Figure 39).

FIGURE 39: Mole Cricket

Nature of Damage: This pest is a polyphagus insect. The adult feeds on the tender roots and basal portions of the growing rice plants. Its damage is higher in raised nursery beds or under upland conditions. It infests lowland rice only when there is no standing water.

Alternate Host: All upland crops.

Life History: The adult female lays eggs in hardened cells which are constructed in the soil by the female. One cell contains about 30 to 50 eggs. The hatching nymphs feed on roots, damaging the crop in patches. This insect has one to two generations per year. The mole cricket cannot live in flooded fields and they swim across the water to the leaves. They burrow in the leaves and lay eggs. Whenever the water level in the field recedes, they migrate to the field to feed.

Control:

1. Flooding the field can effectively control the pest when infestation is heavy.

2. Trapping the adults in the light traps (see rice bug, page 105).

3. Spreading poisoned rice bran in infested rice fields also controls this pest.

4. In nursery bed Lindane granules @ 0.5 kg a.i./ha.

U14.10 ARMY WORMS

Since the larval form of these insect pests appears suddenly in large numbers they are called army worms. Two species namely: Common Army Worm or ear cutting caterpillar and Rice Swarming Caterpillar occur sporadically in different regions of Nepal.

1. Common army worm (Mythimna separata)

Nepali name: Phauji Kira

Identification: The adult moth is brown in colour. A clear white blotch is present at the centre of the fore wing. The larva is greenish or pinkish or a mixture of both and has a dark brown head. The larva has five black stripes running along its body.

Nature of Damage: Damage is caused by larval feeding on leaves except midrib and stem. These larvae also cut the panicle at the base. Newly hatched larvae feed on green parts of the leaves and after some time they are scattered and feed by making holes in the leaves. They are active only during the night. In the daytime they hide inside the soil or near the base of the plant or beneath the plant trashes.

Alternate Host: This pest is a polyphagous insect. It can attack maize, wheat, barley, sorghum, sugarcane, millet, tobacco, bean, turnip and other grasses.

Life History: The adult moths are nocturnal and strongly phototropic and remain quiescent during the day. The female moth lays eggs in between the leaf sheaths and the stem near joint of the leaf sheath and the leaf blade. The eggs are covered with a white adhesive substance. A single female can lay about 500 eggs in its life. The female and male moths live for 7 and 3 days, respectively. In one year they can have 3 to 5 generations. The life cycle is shown in Figure 40.

During winter the larvae remain hidden inside the stubble or soil, when summer begins they again start feeding after which they pupate inside the soil.

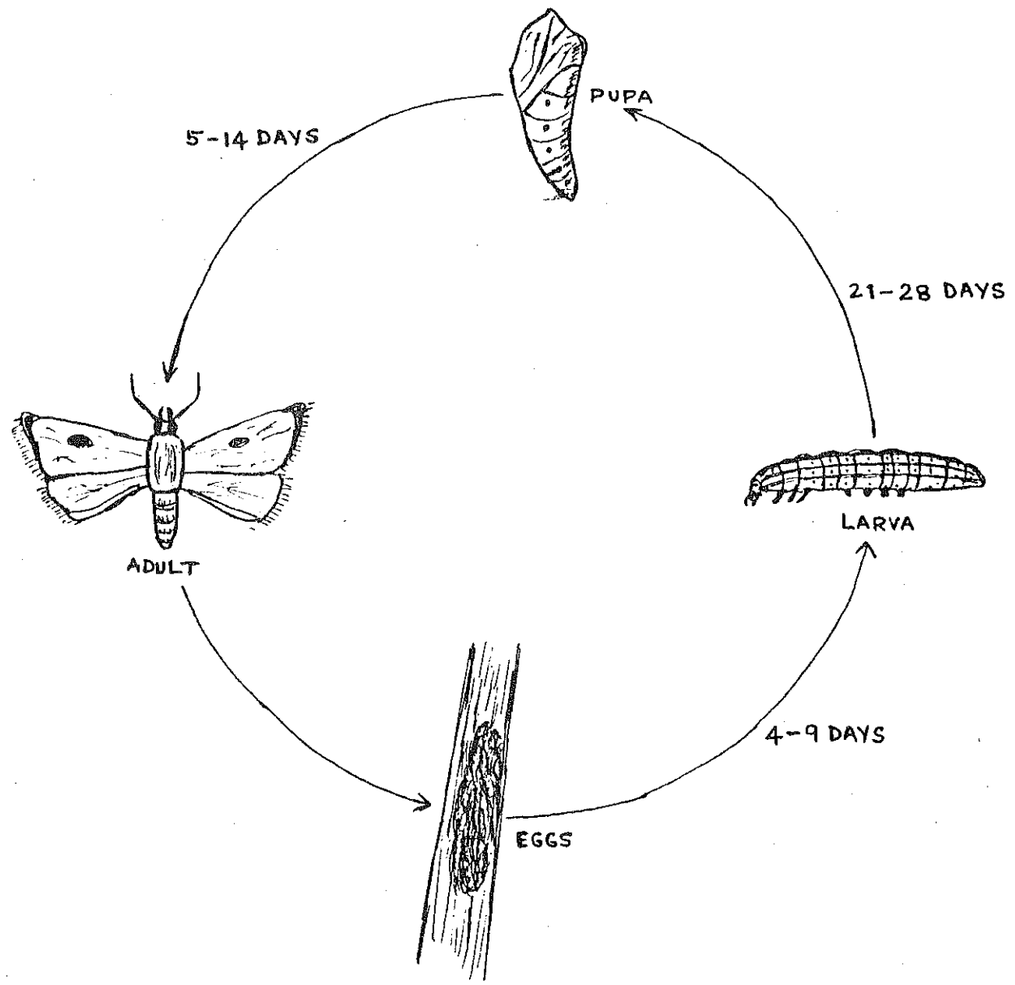


FIGURE 40: Life cycle of Army Worms

Control:

1. Burning of stubble.

2. Ploughing up of fields after harvest.

3. Wherever possible, flooding fields (completely submerge stubble) for 4 days destroys both larval and pupal stages.

4. Early maturing varieties escape the damage.

5. For insecticidal use refer to the rice bug. However, insecticides should be used immediately as soon as early stage of damage is noticed.

2. Rice Swarming Catarpillar (Spdoptera mauritia)

Nepali name: Phauji Kira

Identification: The adult is a greyish black moth with a dark blotch on its forewings. The full grown larva is dark to pale green with dull dorsal and subdorsal stripes. Their colour varies greatly.

Nature of Damage: Rice swarming caterpillar feed mainly on young rice plants in seed beds or shortly after planting out, and destroy them within a short period. When a field has been stripped bare, they migrate in large numbers into adjoining fields to continue feeding at night.

Alternate Host: maize, sorghum, sugarcane, mustard and many other grasses.

Life History: The moth is active only after dark but during the day hides crevices in the soil or under other cover. The female moth lays eggs in a mass on the lower or upper surface of the leaves of rice and other grasses and are covered with greyish hairs. Each egg mass contains about 300 eggs. A single moth lays about five to six egg masses. Newly hatched larvae feed by scraping green matter from the leaves. The full grown larva, when disturbed, curls into ring. Pupation takes place in earthen cells, slightly below the ground level, and the pupa is dark brown in colour. Its life cycle is almost similar to that of common army worm.

Control:

1. Flooding fields force larvae to stay on the plants which they defoliate by feeding and are thus exposed to birds and other predators. Flooding also kills some hidden larvae.

2. Use of ducks in the rice fields can also kill many hidden larvae.

3. Digging a trench (1 to 1.5 m deep) around the infested field prevents the migration of larvae to the adjoining fields. The larvae trapped inside the trench can be killed by effective contact poison or by drowning in water or by burning them with any means. However, it can be solved with the effort of a particular community.

U14.11 RED WORM (LIMNODRILUS SP.)

Nepali name: Rato Kira, Sano Gadyanula

This pest has been noticed in Sunsari, Dhanusa, Makwanpur, Bara, Bhaktapur, Lalitpur, Kathmandu and Tanahun districts of Nepal.

Identification: The red worm (3.5 cm long) is slender and pink in colour. Several worms are seen entangled at the rice root and crown portion of the plant (Figure 41).

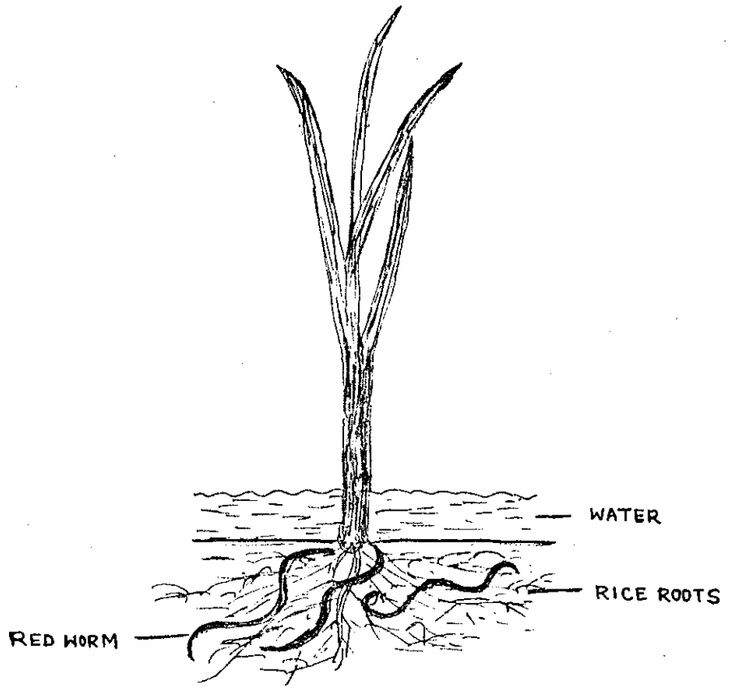


FIGURE 41: Red Worm

Nature of Damage: The drying up of the leaves of the affected plants are generally seen, thus affecting the plant vigor. In the case of severe infestation the whole plant dies.

Life History: This has not been studied.

Control: Since the biology and ecology of this pest have not been studied their control methods cannot be made. However, the application of Furandan 35 0.5 kg a.i./ha has been recommended for the control of this pest.

U14.12 RICE WHORL MAGGOT (HYDRELLIA PHILIPPINA)

Nepali name: Dhank Guboko Aunsa

This pest also occurs every year in the rice season mostly in terai regions of Nepal. However, its epidemic form causing significant losses of crop has not been observed.

Identification: The adults (2 mm long) are grey coloured flies (see Figure 42). The full grown larva (maggot) is cylindrical with posterior and tapering to a pair of pointed spiracles.

Nature of Damage: The larvae mine the leaf sheaths and then move down to the unopened central leaf whorl. The larvae remain in the whorl feeding on the margin of the leaf. Damaged symptoms are visible when the leaf grows out of the whorl. The edge of the leaf is discoloured, whitish or yellowish.

Alternate Host: Echinochloa crusgalli and E. colona

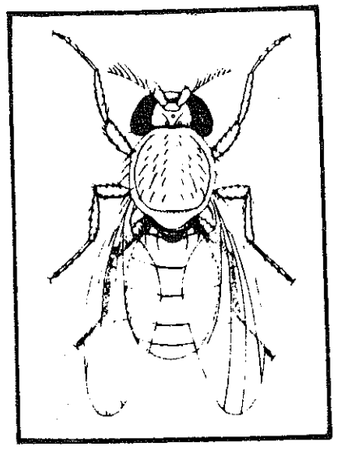


FIGURE 42: Adult of Rice Whorl Maggot

Life History: The adults are active during the day time and can be seen resting on the leaves which are near the water. The female lays eggs singly on either surface of the leaves. Leaves near the water surface usually have the most eggs. Eggs are cylindrical and white in colour. The newly hatched larvae are transparent to light cream in colour. After they begin feeding they become yellowish. The larva, when fully grown, pupates outside the feeding stack.

Control:

1. Remove alternate host from the rice fields to minimize the population build-up of this pest.

2. Most effective and long lasting chemical control can be achieved through soil incorporation of a systemic granular insecticide. (See rice stem borers).

3. Foliar spraying of Sevin 50 WP @ 0.1% or Metacid 50 EC @ 0.05% a.i. is also effective if applied at 10 day intervals during the dry season.

U14.13 SEED BED BEETLE (HETERONYCHUS LIODERES)

Nepali name: Ritthe Kira

This pest is abundant mostly in the Kathmandu valley and foothills of Nepal. This pest does occur in the terai but in very low populations.

Identification: The adult is a medium sized brown or black coloured beetle. The larva (grub) is dirty white in colour with a curved body and light brown head.

Nature of Damage: Both adult and grub feed on the rice roots and the basal part of the stem inside the soil. Their feeding results in the killing of the seedlings. Their population is more abundant in the dry nursery bed than in the wet nursery bed.

Alternate Host: Sugarcane

Life History: One adult beetle lays its eggs near the plant roots or near the heap of farm yard manure. The eggs are white, round and flat in shape. The adult beetles survive for about 2 months. It can have one generation per year. Its life cycle is given in Figure 43.

Control:

1. Destroy the adult beetles and grubs seen during the nursery bed preparation.

2. Use well decomposed farm yard manure (FYM) only, because undecomposed FYM may carry the eggs to the nursery bed.

3. In problem areas use BHC or Aldrin or Chlorodane @ 2.5 kg a.i. per ha in the soil before seeding but at the time of field preparation. Great care should be taken while using these pesticides.

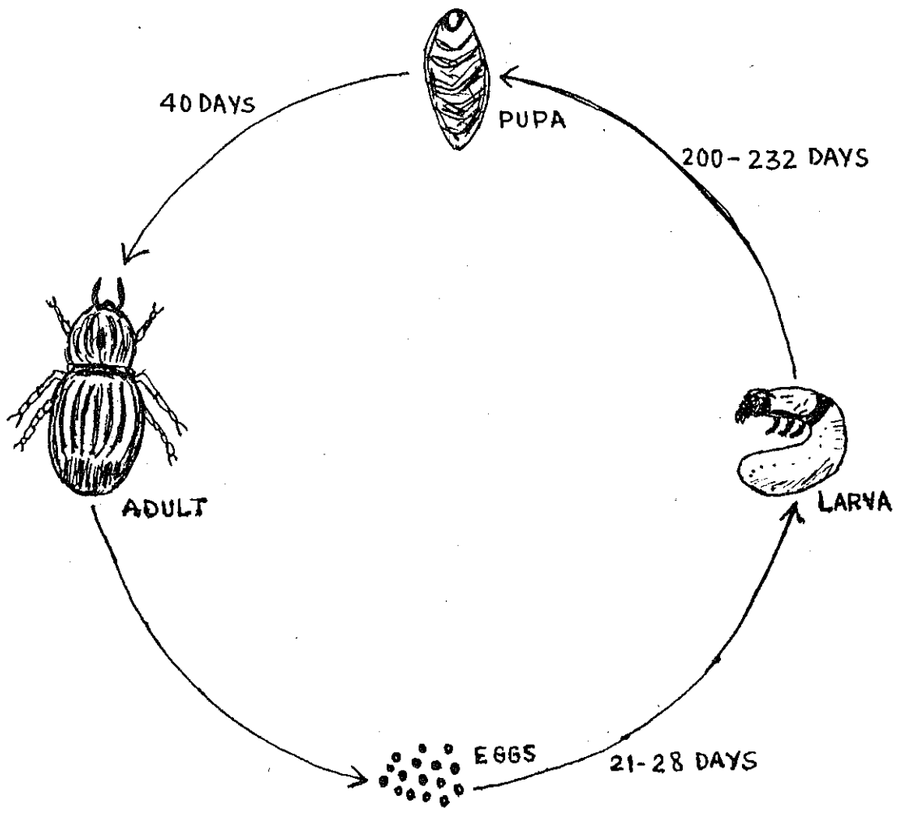


FIGURE 43: Life cycle of Seed Bed Beetle

UNIT 15
DISEASES OF RICE

U15.01 BLAST OF RICE

Nepali Name: Khairo Ankha Rog

The blast of rice is the most destructive disease and is present in the hilly and terai regions of Nepal. This disease is caused by the fungus Pyricularia oryzae cav.

Symptoms

The disease attacks all the above-ground parts of the rice plant.

- The most common symptoms of the disease are elliptical leaf spots with more or less pointed ends (Fig. 44). The spots usually have a grey or whitish center and a brown or redish brown edge. The spots usually begin as small water soaked whitish, greyish or bluish circular dots and when many spots occur, the leaves die.
- When the node is infected it turns blackish, becomes rotten and breaks easily (Fig. 45).
- Infection near the panicle base of ten causes "rotten neck" or "neck rot" and the panicle falls over or breaks (Fig.46).

Source of infection: The fungus survives the winter on infected seeds, stubbles and straw. It also survives on many species of grasses such as Panicum, Digitaria and Setaria which are found in the rice fields. The disease is seed, soil or air borne.

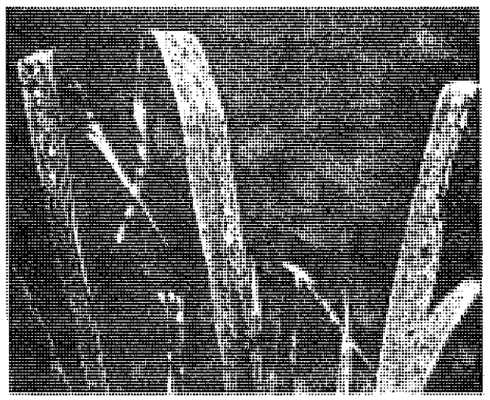


FIGURE 44: Leaf Blast

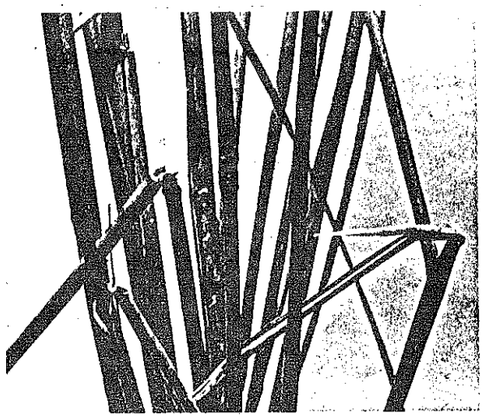


FIGURE 45: Node Blast

FIGURE 46: Neck Rot

Predisposition

The disease develops fast in hot (30 °C) and humid conditions (86 - 96% relative humidity RH).

The application of excessive doses of nitrogenous fertilizers predisposes the rice plant to blast infection.

Also the dense population of rice plants induces an out-break of the diseases.

Rice grown in upland conditions suffer more thant rice grown in flooded conditions.

Control

1. Use the seeds from disease free crops.

2. Treat the seed with Bavistin 50 WP @ 2.5 gm/kg of seed 5-7 days before sowing if it is obtained from a diseased crop or locality.

3. Burning infected plant parts, straw and stubbles minimize the source of infection.

4. Practice frequent weeding of the rice fields to remove the fungus inoculum.

5. Do not use excessive nitrogenous fertilizers (follow recommended dose of fertilizers).

6. Maintain proper spacing of the rice plants in the field to prevent excessive plant population.

7. Use resistant varieties like Himali, IR-8, IR-36, IR-20, IR-29, IR-34 and IR-40 in problem areas.

8. Foliar application of the following fungicides have been found effective in minimizing the disease:

   Hinosan 50 EC @ 1.5 ml/litre of water
   or
   Bavistin 50 WP @ 3 g/litre of water
   or
   Dithane M-45 @ 3g/litre of water
   or
   Difolatan @ 2 g/litre of water
   or
   Kasugamycin @ 1 ml/10 litre of water

The application should be made as soon as the symptoms (especially during booting and panicle emergence) are noticed. Repeat spraying after 10 - 15 days interval to prevent further out-breaks of the disease.

U15.02 BROWN LEAF SPOTS

Nepali Name: Khairo Thople Rog

It is called a "poor management disease". It is a very common disease distributed more or less throughout the country. It is a fungus disease caused by Helminthosporium oryzae.

Symptoms:

It is a foliage disease and can be seen as brown spots on the grain.

- At the initial stage of the disease, minute brown spots appear on the lower leaf and gradually increase with the development of the leaves.
- Oval to circular brown spots with whitish centre. Most spots have a light-yellow halo around their edge (Fig. 47).
- Older leaves die first and younger leaves next and then the young seedlings become blighted in the nursery.
- Infected seeds have minute brown spots on the husk of the grain.

Source of infection:

Use of infected seeds

Infected stubbles and straw

Previously infected soil

Collateral hosts like Echinochloa species and Cynodon dactylon

Predisposition Factors

Water logged and sandy soil supplies poor nutrients to the plants. These conditions make plants more susceptible to this disease. Very high humidity (90 - 98%) and 20 - 26°C temperature is favourable for the spread of the disease.

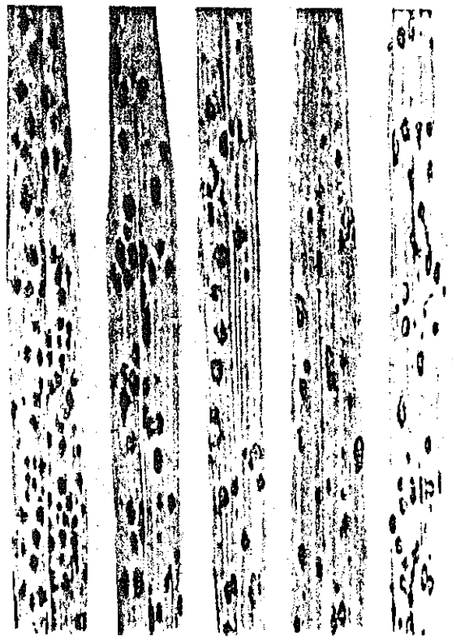


FIGURE 47: Brown Leaf Spot

Control:

1. Improve soil structure with an application of FYM, compost and raise green manure.

2. Use seeds from healthy rice fields.

3. Burn the straw and stubbles previously infected. This helps to minimize the source of primary infection.

4. Use resistant varieties like CH-45.

5. Keep the field free from weeds.

6. Apply zinc sulphate and recommended fertilizers in a split dose, 2 - 3 times.

7. Seed treatment with Ceresan @ 3 gm per kg seed or Bavistin @ 2 - 3 gm per kg seed is effective in minimizing this disease. Seed treatment is done 5 - 7 days before sowing the seed.

8. Foliar spray Dithane M-45 or Dithane Z-78 @ 3 gm per litre of water. Repeat 2 - 3 times with a 10 - 15 days interval.

U15.03 BACTERIAL LEAF BLIGHT

Nepali Name: Pat Dadhuwa Rog

This disease is seen mostly in the terai regions of Nepal. It is caused by the bacterium Xanthomonas campestris pv Oryzae Dowson (Vyeda &Ishiyama).

Symptoms: Bacterial leaf blight is a systemic disease that damages the rice crop in several ways.

- At the seedling stage, the leaves of infected plants or even the entire plant may wilt (Fig. 48). This condition is known as kresek.
- The most common leaf symptom of the mature plant is yellow to white lesions which begin as water-soaked stripes (Fig. 49), wavy or straight at the edges of the leaf blade. This is followed by the drying of the leaf. This condition is referred to as leaf blight.

FIGURE 48: Kresek symptom of Bacterial Leaf Blight

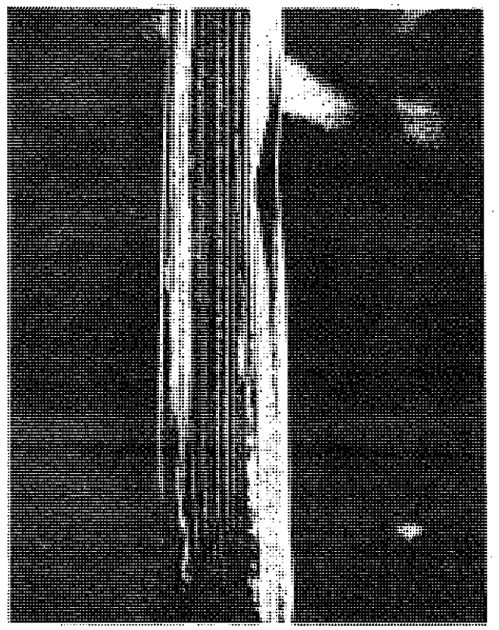


FIGURE 49: Water soaked stripe of Leaf Blight

Source of infection: The bacteria is present in straw, stubbles, ratoons of infected plants, seed and weed hosts. This disease is spread by dew, irrigation water, rain, flooding, and strong winds.

Predisposition: The bacteria can invade rice plants, either through the roots and basal stem that have been injured when the young plants are pulled from the seed bed, to insect attack, or during the weeding. High nitrogenous fertilizers favour blight epidemics.

Control:

1. Use seeds obtained from disease free fields.

2. Burn diseased straw, stubble and eliminate weed hosts and rotten rice plants.

3. Raise seedlings in upland nurseries.

4. Control the level as well as flow of irrigation water from the infected field.

5. Apply nitrogenous fertilizers in suitable amounts while increasing the amount of potash by 15% to that recommended in the problem areas.

6. Prevent plant injuries (especially due to insect attacks, during weeding rice fields or uprooting seedlings from the nusery beds) since bacteria can enter the plant system through the portion injured.

7. Use of resistant varieties is the most effective and economical method to control bacterial leaf blight. Some of the resistant varieties are CH-45, IR-8, IR-20, IR-22, IR-26, IR-28, IR-30, IR-36, Takmare, Thapachini, Bhadaiya, Thaali, Ghaiya, Sajani, Lalsar, Maturi, Basmati, Lachara-ghaiya, Sano Bagni, Dolkha Masino, Budhabir, Hawa Nimuwa, Saro, Gadhar, Dudhi, Kotanjhar, Sokan, Nokchi, Janki, Pokhareli Masino, and B-446.

8. Soaking the infected seeds (or suspected infected seeds) in a streptocyclin or Agrimycin 100 solution (both anti-biotics @ 3 g/10 litres of water) for 12 hours, has been found effective in controlling the initial infection.

9. The spread of a secondary infection has been reported to be controlled by the foliar spraying of Neo-sankel @ 2.5 g/litre of water. However, 3 or 4 applications are necessary at an interval of 10 - 15 days to obtain good results.

10. Use of Bleaching powder @ 2 kg/ha with irrigation water or field water has also been found effective in minimizing the disease.

U15.04 SHEATH BLIGHT

Nepali Name: Danth Ma Kalo Hune Rog

It is also a major disease of rice in Nepal and is found throughout the country. The sheath blight is caused by fungus Rhizoctonia solani Kuhn.

Symptoms: The fungus causes spots on the leaf sheaths and on the leaf blades.

- The spots are at first small, elliptical or oval and greenish grey. They enlarge and may coalesce forming bigger lesions with irregular outlines having greyish white with brown edges (Fig. 50). The presence of several large spots on leaf sheaths causes the death of the whole leaf.
- The leaf blades in contact with adjacent infected stems also become infected.

FIGURE 50: Sheath blight symptom

Source of infection: The fungus (sclerotia) can survive in the soil for several months. The sclerotia float to the surface of the water during soil puddling, levelling and weeding and infect the plants which they come into contact with.

Predisposition: The disease becomes more severe during warm tempertures (28 - 32°C) and high humidity (96% relative humidity).

Close planting and high usage of nitrogenous fertilizer also increases the incidence of the disease.

Control:

1. Draining the fields will control the disease to a certain extent.

2. Use moderately resistant varieties like IR-8, IR-20 and IR-26 in the problem areas.

3. In heavily infected patches, soil drenching with 0.1% wet cerasan, @ 12 litre/m² was found useful.

4. Soil treatment with Thiram @ 25 kg/ha has been recommended in the highly problematic areas.

5. As soon as symptoms are seen, spraying with either Bavistin 50 WP @ 2.5 g/litre of water or Benlate @ 2.5 g/litre of water has been found effective against this disease. However, 2 - 3 sprayings are needed for effective control.

U15.05 BACTERIAL LEAF STREAK

Nepali Name: Pat Dharke Rog.

It is a major foliage disease of the Terai and the Inner Terai areas. It is a bacterial disease caused by Xanthomonas campestris pv. oryzicola.

Symptoms:

The symptoms of the disease appear only on the leaf blades.

- Long brown streaks form between and parallel to the veins (Fig. 51).
- Entire leaves of susceptible varieties may turn brown and die at a later stage of the disease development.

Source of infection:

Infected seeds and water coming from the infected rice fields.

Predisposition

An application of excessive nitrogenous fertilizers to dense population.

High humidity of 83 - 93% and temperature of 26 - 30 °C is favourable for the spread of the disease.

Rains, storms and strong winds help to spread the disease.

Bacteria enter the plant through mechanical injuries (by insects like rice hispa and leaf hoppers) or a natural cell opening.

FIGURE 51: Bacterial Leaf Streak

Control:

Use the seed from healthy fields.

Do not apply excess dose of nitrogenous fertilizers.

Keep the field free from weeds.

Avoid close planting (should not be less than 20 x 20 cm plant to plant and row to row).

Control insects like leaf roller, rice hispa to prevent infection. Seed treatment for 12 hours with streptocycline @ 1 gm/10 litres of water is effective in minimizing the disease.

U15.06 SHEATH ROT

This disease is of minor importance in Nepal. It is caused by the fungus Acrocylindrium oryzae.

Symptoms: This disease occurs on leaf sheaths during tillering stage. Greyish-brown lesions with brown edges formed chiefly on the uppermost leaf-sheaths enclosing the young panicles. They enlarge and often coalesce and may cover most of the leaf sheaths and the young panicles remain within the sheath or only partially emerge. An abundant whitish powdery growth may be found inside affected sheaths and young panicles are rotted.

Source of infection: Infected seeds and straw.

Predisposition: Wounding of the plants facilitates infection.

Control:

1. Use disease free seeds.

2. Burn the infected straw in the field.

3. In places having irrigation facilities, frequent draining of water from the infested fields helps to minimize the spread of the disease.

4. Prevent wounding the plants (either during weeding or insect attack).

U15.07 STEM ROT

Nepali Name: Danth Kuhine Rog

This disease is mostly found in the valleys and the terai regions of Nepal. It is caused by the fungus Helmithosporium sigmoidium Cav.

Symptoms: The first symptom of the disease is the appearance of small, black, irregular lesions on the outer leaf sheath near the water line. When the affected plants are cut open, numerous black sclerotia (fungus) is seen inside the stem (Fig. 52).

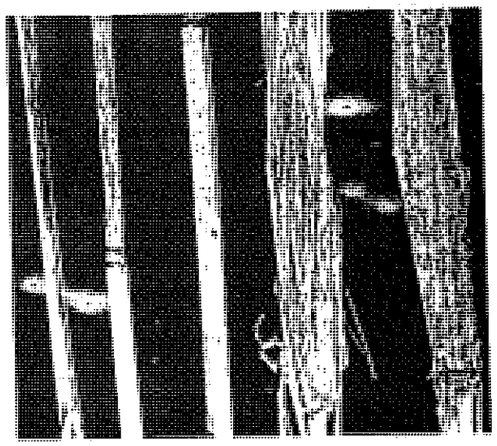


FIGURE 52: Stem Rot

Source of infection: The sclerotia (fungus) survives in the soil, stubble and straw during the off season and serves as the primary source of inoculum. They are spread from field to field by irrigation or flood water.

Predisposition: Application of nitrogen increases the intensity of disease. Insect attack, particularly stem borer incidence also increases the intensity of the disease.

Control:

1. Burn infected rice stubbles and straw as this will reduce the source of the infection.

2. Follow crop rotation by changing the cropping pattern if possible.

3. Use only suitable amount of nitrogenous fertilizers and increase potassic fertilizers by 5% in the recommended doses.

4. Prevent stem injury from insects by the regular application of insecticides.

5. Irrigation water should not be directed from an infested to a non-infested field.

6. Draining off the irrigation water and allowing the soil to dry has been found to control the disease and when done with care, appears to be the best method.

7. After draining the water, drench the soil with 0.1% cerasan wet 3 times during the growing period in the main field. This was reported to effectively check the disease.

8. Drenching the soil with Thiram, @ 25 kg/ha before transplanting, has also been found effective in minimizing the disease.

U15.08 FALSE SMUT

Nepali Name: Kalo Poke or Hariyo Pahelo Poke Rog.

This is considered a minor disease and is distributed throughout the country. It is a fungus disease caused by Ustilaginoidea virens.

Symptoms:

Some grains of a panicle are converted into green velvet spore balls. Finally the green balls change into a black colour.

Source of infection:

Infected seeds
Previously infected fields

Predeposition:

Use of high dose of nitrogenous fertilizer.
Use of susceptible variety.

Control:

1. Use of disease free seed.

2. Collect the affected panicles in polythene bags during the morning hours and burn it.

3. Crop rotation with other crops.

4. Avoid excessive application of nitrogenous fertilizers.

5. Seed treatment with Ceresan @ 2 - 3 gm/kg of seed and with Bavistin @ 2 gm/kg of seed.

6. Spraying of Bavistin 50 WP @ 2 - 3 g/litre of water before emergence of panicle. Two sprayings are necessary at an interval of 15 days.

FIGURE 53: False smut

U15.09 LEAF SCALD

Nepali Name: Pat Daduwa Rog.

It is a minor disease in the hilly and terai regions. This disease is caused by the fungus Rhynchosporium oryzae Hashioka & Yokogi.

Symptoms: The disease usually occurs on mature leaves, mostly near the tips, but sometimes starts at the edge of other parts of the blade. The lesions are oblong or diamond shaped, water-soaked blutches. As the lesions enlarge, they coalesce together resulting in blighted areas of the leaves. Finally severely affected leaves dry and turn to a bleached straw colour with a brown edge.

Source of infection: Infected seeds.

Predisposition: Leaf scald is more common on plants receiving high doses of nitrogenous fertilizers.

Control:

1. Use the seeds from disease free plots.
2. Avoid application of excessive doses of nitrogenous fertilizer (use only the recommended dose).
3. Seed treatment with Thiride, @ 3 g/kg or Diathane M 45, @ 3 g/kg has been found effective in minimizing the disease.

U15.10 NARROW BROWN LEAF SPOT

Nepali Name: Masino Khairo Pat Thople Rog

It is prevalent throughout the country, however, it is of minor importance. This disease is caused by fungus Cercosporo oryzae Miyake.

Symptoms: This disease produces short, linear, brown lesions on leaves and may occur on leaf sheaths, pedicels and glumes. The long axis of each spot is parallel with the leaf vein (Fig. 54).

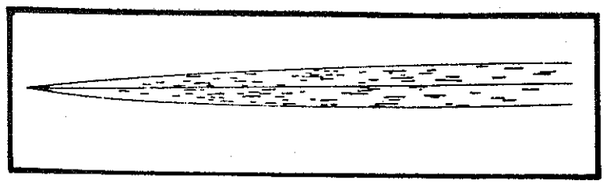


FIGURE 54: Narrow brown leaf spot

Source of infection: The manner in which the fungus survives from one season to the next as well as its dissemination is not known.

Predisposition: Conditions favouring development of this disease is also not known.

Control:

1. Use the seeds obtained from the disease free fields.
2. Foliar spray with Bavistin, @ 2 g/litre of water or Diathane M 45, @ 2.5 g/litre of water has been found effective in minimizing this disease. However, 2 or 3 sprayings are necessary for good results.

U15.11 RICE TUNGRO VIRUS

Nepali Name: Pahelo Suntala Pat Hune Rog.

This virus is transmitted by green leaf hoppers. Nephotettix virescens.

Symptoms:

- The plants remain small, leaves lose colour and flowering is delayed.
- The number of tillers is slightly reduced.
- The tips of the green leaves become yellow and change finally to orange.

Control:

There is no known method for curing virus infected rice plants under field conditions.

1. Remove virus infected plants from the rice field.

2. Foliar spray with any insecticides to control green leaf hoppers (refer control of green leafhoppers, see page 119).

3. Field sanitation (weeding) helps to prevent the disease.

4. Burn the stubbles which previously infected the crops.

5. Use of resistant varieties such as: Peta, Basmati-370, IR-36, IR-68.

U15.12 RICE DWARF VIRUS (RDV)

Nepali Name: Dhan Chhoto Hune Rog or Thingure.

This virus was reported from the Kathmandu valley and Parwanipur and it is transmitted by green leaf hoppers Nephotettix apicalis and N. cincticeps.

Symptoms:

- The plant remains small with green leaves which are darker than normal green leaves.
- Infected leaves have large numbers of tiny transparent stripes which stick together and form long lines parallel to the midrib.

- The roots and shoots are reduced.
- The panicle may be absent or shorter in size.

Control:

There is no known method for curing virus infected rice plants under field conditions.

1. Remove virus infected plants from the rice fields.

2. Use a foliar spray with any insecticide to control green leaf hoppers (refer control of green leaf hoppers).

3. Field sanitation helps to prevent the crop from disease.

4. Use of resistant varieties, such as IR-20, IR-2071-627-1, IET-2938 and Tepet can be grown in problem areas.

U15.13 WHITE TIP

Nepali Name: Seto Tuppa

This disease was reported recently from the Kathmandu valley in an epidemic form. It is caused by the nematode (rice leaf nematode) Aphelenchoides bessevi christie.

Symptoms:

In the field, the symptoms of white tip usually become evident in the beginning of the elongation of the plants. The upper leaves, particularly the flag leaf of severely diseased plants,

are markedly twisted. The infected leaves are darker green than normal and severely infested plants are stunted. The panicles are shorter and the ear size is reduced. The grains are smaller than normal and often deformed. Maturation of infested panicles is retarded.

Source of infection:

The nematodes can be spread with infested seed and plant residues and some times by flood water. The nematodes can survive for three years on dry stored grain and up to nine months in the soil.

Predisposition:

Most favourable temperature range for the development of this nematode is between 21-25 °C. No development below 13 °C.

Control:

1. Use the seeds obtained from the disease free fields.
2. Avoid the flow of water from infested to non infested fields.
3. Clean tools and equipment thoroughly before using them in the field.
4. Follow crop rotation for at least three years if possible.
5. Seed treatment with Benlate @ 3 g/kg was found to be effective in eliminating the nematodes.

UNIT 16
APPLICATION OF PESTICIDES

U16.01 PESTICIDE APPLICATION SCHEDULE

The insect pests and diseases can damage rice plants at its different growth stages. Therefore, first determine the extent of damage and only if the damage is at economic level application of pesticides is recommended. However, in problematic areas, the general pesticide application schedule, as given below, can be followed.

1. Soil treatment in the Seed Bed

For soil insect pests, use BHC, Aldrin or Chlorodane dust @ 2 kg a.i./ha at the time of seed bed preparation.

2. Foliar Spraying in the Seed Bed

For foliage insect pests, use Metacid 50 EC (@ 0.05% a.i.), Thiodan 35 EC (@ 0.07% a.i.) or Sumithion 50 EC (@ 0.05% a.i.) 12 - 15 days after seeding. Whereas, use Hinosan 50 EC (@ 1.5 ml/litre of water), Bavistin 50 WP (@ 3 g/litre of water), Diathane M-45, wettable powder (@ 3 g/litre of water) or Diathane Z-78, wettable powder (@ 3 g/litre of water) for control of foliar diseases such as blast, brown leaf spot and narrow brown leaf spot.

3. Foliar Spraying in the Transplanted Field

The same insecticides (at the same rate) which have been recommended for foliar spraying in the seed bed can also be used in the transplanted field.

- First spraying: 20 - 30 days after transplanting
- Second spraying: 40 - 50 days after transplanting
- Third spraying: 70 - 80 days after transplanting
- Fourth spraying: 90 - 100 days after transplanting.

The fourth spraying may not be necessary for early maturing varieties, such as CH-45, Chandina and Parwanipur-1.

The earlier mentioned fungicides at the same rate can also be used for the control of foliar diseases in the transplanted field. However, 4 - 5 sprayings are necessary at an interval of 10-15 days for effective control. First spraying is done as soon as early symptoms of diseases are noticed.

4. Application of Granules

The application of granular insecticides such as Furadan 3G, Thimet 10G, or Dizinon 10G can be made @ 1 - 2 kg a.i./ha (increase the amount with the age of the plants) as an alternative to foliar sprayings. The first application should be made 20 - 30 days after transplanting. The interval between two applications is 20 - 25 days. The granular application needs 4 - 5 cm of standing water in the fields and the water should not be drained at least for 5 days.

DO NOT USE BARE HANDS FOR THE BROADCASTING OF THE GRANULAR INSECTICIDES, USE RUBBER GLOVES FOR THIS PURPOSE.

U16.02 PESTICIDE CALCULATIONS

Accurate calculations are important if pesticide applications are to be effective and economical.

- Application at rates lower than those recommended may not provide effective control, whereas rates higher than recommended is a waste of money and may well cause phytoxicity.
- Pesticide recommendations are based on research and their rates are expressed as a kilogram of active ingredient per hectare (kg a.i./ha) or as a percentage concentration of active ingredient (% a.i./ha) in the final diluted pesticidal solutions.
- Every pesticide has an active ingredient (a.i.), the principal chemical compound (toxicant) that acts on the pest. In its pure form, the toxicant may be solid or liquid.
- Since the pure form of pesticides is highly toxic, manufacturers dilute it before making it available to farmers.

REMEMBER AGAIN: USE ONLY THE RECOMMENDED DOSE OF PESTICIDE FOR PEST CONTROL.

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 (chalk dust or pure clay soils). The concentration of the a.i. is thus expressed as a percentage of the weight of a.i. in the total weight of the commercial solid formulations, 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

1. BHC 5% dust means that there is 5 grams of pure BHC (toxicant) in every 100 grams of commercial 5% dust.

2. Sevin 50 WP means that there is 50 grams of pure carbaryl (toxicant) in every 100 grams of commercial 50% powder.

3. Furadon 3G means that for every 100 grams of commercial Furadon granules there are 3 grams of pure Furadon (toxicant).

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 a.i. is thus expressed in two ways:

$$\text{Percentage, \% a.i. in EC} = \frac{\text{Weight of a.i. x 100}}{\text{Volume of EC}}$$

Example:

a) Metacid 50 EC means that for every 100 millilitres (ml) of the commercial Metacid liquid there are 50 grams of pure methylparathion (toxicant).

b) Grams per litre:
Example: In one litre of commercial Folithion (insecticide) liquid, 1000 grams of Fenitrothion (toxicant) is present.

Calculations

The factors which must be known when making the calculations are as follows:

1. The % a.i. of the pesticide in the commercial formulations.

2. The recommended rate in kg a.i. or liters a.i. per hectare or % concentrations to be applied.

3. Amount of spray solution (in litres) desired per area to be treated.

4. Area (in hectare) to be treated.

When the recommendation is in percentages of an active ingredient, the following formulas are suggested:

For an emulsifiable concentrate (EC)

$$\text{Millilitres of EC required} = \frac{\text{\% a.i. in spray solutions} \times \text{Liters of spray solutions required (litres)} \times 1000}{\text{\% a.i. in commercial EC}}$$

Example: To control rice bugs, 30 litres of 0.05% methyl parathion should be prepared. The emulsifiable concentrate Metacid to be used contains 50% methyl parathion. What is the required volume of Metacid?

Given:
a) % a.i. in commercial EC = 50%
b) Litre of spray solution required = 30 litres
c) % a.i. in spray solution = 0.05% a.i.

Calculation:

$$\text{Millilitres (ml) of Metacid required} = \frac{0.05 \times 30 \times 100}{50} = 30 \text{ ml of Metacid 50 EC}$$

Example: To control green leaf hoppers, carbaryl should be applied at the rate of 0.1% a.i. Sevin wettable powder, containing 50% carbaryl, is available. How many grams of Sevin are needed for 60 litres of spray solution?

Given:
a) % a.i. in commercial WP = 50%
b) Litres of spray solution required = 60 litres
c) % a.i. in spray solution = 0.1%

Calculation:

$$\text{Grams of Sevin required} = \frac{0.1 \times 60 \times 1000}{50}$$

= 120 grams of Sevin 50 WP

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

$$\text{kilograms (kg) of WP or granules required} = \frac{\text{kg a.i./ha (recommended)} \times \text{Area to be treated (ha)} \times 1000}{\text{\% a.i. in WP or granules}}$$

Example: Furadan 3G granules containing 3% a.i. is recommended to control rice stem borers at a rate of 2 kg a.i./ha. How many kilograms of Furadan 3G are needed for a 3,000 sq.m. plot?

Given:

a) % a.i. in Furadan 3G = 3% a.i.
b) Recommended rate = 2 kg a.i./ha
c) Area to be treated = 3,000 sq.m. = 0.30 ha.

$$\text{kilograms of Furadan 3G} = \frac{2 \times 0.30 \times 100}{3}$$

= 20 kg of Furadan 3G

U16.03 SPRAYER CALIBRATION

The calibration of sprayers is necessary to determine the application rate of a sprayer, the number of sprayer loads to treat a given area and the amount of pesticide to mix in each load.

The rate of application of sprayer depends on the following factors:

1. Pressure in the spray tank: It should be kept as constant as posible. A pressure gauge is usually provided or can be fitted in the hand compression sprayer. In the knap-sack sprayer it is somewhat difficult to calibrate, since the pressure gauge is absent and thus pressure is determined by the sprayman. However, this can be made more accurate by maintaining the number of pumps in rhythm with the number of steps made.

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

3. Spray swath: It is the width covered by the spray solutions in one passing during which the sprayman repeatedly swings the nozzle from left to right as he walks. It is directly affected by the distance between the nozzle tip and the top of the plant or ground level.

4. Walking speed of sprayman: The speed of walking determines the area covered per unit time. With some practice the sprayman will be able to maintain constant speed.

The following procedures should be followed for the calibration of the hand compression sprayer.

a) Prepare sprayer for the calibration:
   - Remove and clean the nozzle
   - Rinse and fill the sprayer tank with clean water
   - Apply pressure and check for leaks

- Flush pump, hoses and lance with clean water with nozzle and strainers removed.
- Replace nozzle and strainers.
- Refill the tank with measured volume (½ to ¾ of sprayer's capacity) of clean water and apply pressure.

b) Mark the area of about 20 - 50 sq.m. and spray over it.

- Do this in an actual paddy field to be treated
- Carry sprayer on back and operate it as in actual spraying; direct the nozzle at the distance of approximately 30 cm from the top of the rice plant and walk at constant and normal speed (0.5 m/sec)
- Stop spraying once the marked area has been sprayed
- Repeat spraying 3 or 4 times to spray same area

c) Determine the volume of water used for spraying the already marked area.

- Measure the volume of water left after spraying the fixed area and reduce this volume from the initially filled water
- Compute application rate per sq.m. or per ha

Example: Initially filled water in the spray tank is 6 litres. If the amount of water used for 3 times spraying of 20 sq.m. is 4 litres, find the application rate of the handcompression sprayer (in terms area covered for certain volume of water).

Given: Initial volume = 6 litres
Area of water covered = 3 x 20 sq.m. = 60 sq.m.
Final volume of water = 4 litres
Volume used for 60 sq.m. area is = 2 litres

$$\text{Application rate} = \frac{\text{Area covered (sq.m.)}}{\text{volume of water used (litres)}}$$

$$= \frac{60 \text{ sq.m.}}{4 \text{ litres}}$$

$$= 15 \text{ sq/litre of water}$$

For one hectare (10,000 sq.m.) the calibrated sprayer will require = $\frac{10,000}{15}$ = 666.66 litres of water

U16.04 CARE AND SAFE USE OF PESTICIDES

Pesticides are toxic to man and other animals and some of them retain their residual effect long after application. Care should always be taken in storing, handling and using pesticides with regard to their poisonous nature. The following safety precautions should always be taken in handling and using pesticides.

- Read the label of the container carefully and understand the meaning before opening any pesticide and strictly follow its instructions and precautions each time before using it.
- Keep pesticides out of the reach of children, irresponsible people, live stock and away from food as well as animal feeds.
- Always keep pesticides in their original container and lock it up when not in use.
- Never eat, drink or smoke while working with pesticides.

- Wear protective clothing when using pesticides: gloves, water proof overcoat, face mask, goggles, hat, gumboots and respirator.

- Avoid spilling pesticidal dusts or sprays on skin or cloth. If they are spilled, remove contaminated clothing and wash thoroughly with soap and water.

- Keep food and water covered when treating around domesticated or livestock area. Do not contaminate fishponds or any water reservoirs.

- Always wash hands, face and change to clean clothing soon after spraying or take bath with soap and water. Also wash clothing each day before reuse.

- Use separate appliances for applying hormone-based herbicides in order to avoid accidental injury to susceptible plants.

- Always dispose of empty containers so that they cannot harm man, animals or valuable plants.

- Observe label instructions and precautions to keep pesticidal residues on edible portion of plants within the limits.

- Apply pesticides at the recommended rate of concentration and do not mix those which are not compatible.

- Never allow unskilled persons and children as well as those who are allergic to pesticides, to use pesticides.

- Dusting should be carried only when the wind is calm and the plants are still wet.

- Never spray during midday when the sun is too hot.

- During flowering period of the rice plants spray only after 3 pm.

- Spraying/dusting should not be carried in the opposite direction to the wind.

- If somebody accidentally swallows some pesticide or if symptoms of illness occur during or shortly after use, make operator vomit or send him to a doctor with the name and strength of the pesticide (container of the pesticide should be also brought with the patient).

U16.05 EMERGENCY TREATMENTS FOR PESTICIDE POISONING

When poisoning occurs, call a doctor immediately 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. If possible, bring the original container of the pesticide to the doctor. The doctor will advise what to do until he arrives.

Remove the cause of poisoning if one cannot reach a doctor. Some techniques to remove the poisoning are as follows:

For Swallowed Poison:

1. Induce vomiting by putting a finger or tongue depressor down the patients throat until he vomits. Unconscious persons should not be allowed to vomit. Give person salt water to drink (one glass warm water and one teaspoon of common salt) or mix one glass of water and one teaspoon of ground rape seed). Give either any one of these mixture 3 or 4 times until all poison is out through vomiting.

2. Give raw eggs, milk or a thin flour paste after the stomach has been emptied. These help soothing the throat and stomach and also serve to absorb poisons.

3. Give an appropriate antidote (substance that relieves, prevents or counteracts the effect of poison). For chlorinated hydrocarbon, such as BHC, Aldrin, Thiodan, perform gastric lavage and give saline laxative. The doctor may give "phenobarbital" or "pentobarbital" to control convulsions. In certain cases calciumgluconate has also been found effective.

For organophosphorous insecticides, such as Metacin, Dimecron, Metasystox, Folithion etc. the doctor may give atropine sulfate or protopam chloride (also known as paralidoxime chloride and 2-PAM).

For zinc phosphide, after vomiting, give 5 g potassium permagnate ($KMnO_4$) in one glass of warm water. Ten minutes later, give half teaspoon of copper sulfate in one glass of water. Again after 15 minutes, give two teaspoon of "Magnesium sulfate" (Epsom salt in one glass of water).

For Warfarin, if it has been taken for the first time, give milk diet, once only in 24 hours. If this rodenticide has been consumed for several times (by mistake), he/she should be given intravenous injection of Vitamin K.

First day 65 mg for 3 times a day, then go on reducing the quantity. The injection is given until the level of "Prothrombin" in blood is normal (this will be known only by the doctor). Vitam K and Menadione (water soluble) should also be given orally. If excess amount of warfarin has been consumed, along with sufficient Vitamin K, blood tranfusion is also necessary.

For inhaled Poison:

1) Remove patient to open air (wear a mask if entering spray area) and keep him warm.

2) Give artificial respiration by mouth to mouth suction. This is done only if the patient is not breathing.

3) Give appropriate antidote (see for swallowed poison).

For phosphine gas (celphos, phostoxin, phosfume).
In case of pulumonary Oedema (swelling of lung, which can be detected only by the doctor), hypeton glucose solution should

be injected in the patient's body. In some cases comple blood transfusion as well as injection of isotonic saline or glucose solution into the blood is necessary. In general condition, artificial respiration as well as medicine which entrance blood circulation is required.

For spilled Poison on Skin and Cloth:

Wash skin and cloth with soap and plenty of water for several times (at leat for 10 minutes).

UNIT 17
INTEGRATED PEST MANAGEMENT IN RICE

1. Use of healthy seed:

Select the seeds from disease free fields of rice with your own eye.

WHY?

- it is the best method to prevent the disease infection.
- it is the easiest and cheapest and practicable in the field.

2. Seed treatment:

To kill the pathogens with chemical or other treatment, treat the seed with Thiram, Cerasan, Thiride, Bavistin for fungus diseases and streptocycline for bacterial diseases.

- it prevents the crop from primary infection.
- it costs less and takes less time compared to disease control.

3. Use of farm yard manure, green manures and recommended fertilizers:

Use of FYM, green manures not only improves the physical structure of the soil but also increases the capacity of the crop to resist disease.

- in the case of disease occurence less nitrogenous and more potasic fertilizer should be used.

4. Use resistant varieties in problem areas

Information about resistant varieties are given under preventive measures.

- it is the cheapest and easiest method.

5. One foliar spray of pesticides in the nursery bed is very necessary

Because

- most of the pest populations can be restricted in the main field.
- farmers can manage it easily because the area is small.
- it saves time and costs of pesticide.

Wider spacing transplanting in disease prone area:

- provides circulation of air, light, thereby there is less occurance of diseases.

7. Sanitation: Keep the field free from weeds and alternate hosts.

- weeds not only compete for plant nutrient, space, sunlight but also provide shelter for pathogens and insects.

8. Flooding and drying of field:

Reduces disease and insect intensity.

9. Care of predators:

Tiger beetle, spiders and lady bird beetles are predators and regulate the pest population (see Fig. 54).

10. Harvest the crop near to the ground:

This method of harvesting helps to control stem borer and gall midge.

11. Deep ploughing:

Deep ploughing during high sunshine periods helps to reduce disease and insect intensity.

12. Flood the harvested field:

Flood the harvested field for 5 - 6 days continuously.

13. Rouging:

Rouge out also smutted panicles and virus affected plants and burn them.

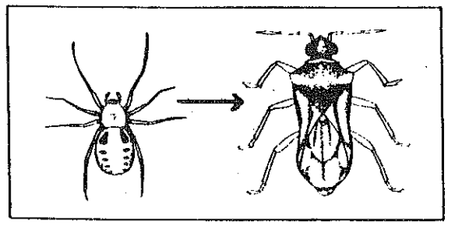
14. Burn the straws and stubble of disease infected fields.

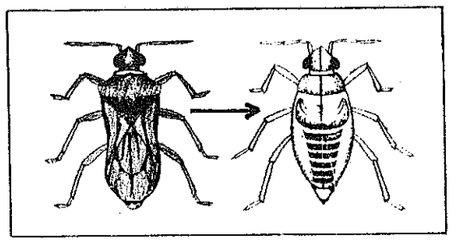
15. Look for Predators and parasites of insect pests in the rice field. If their population is high enough do not spray chemicals.

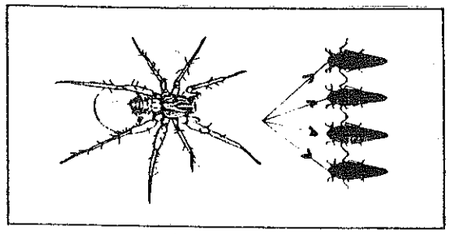
16. If all methods (mentioned earlier) are not enough to maintain the insect pest population below the damaging level (economic threshold) then only follow the application schedules of pesticides, as described earlier.

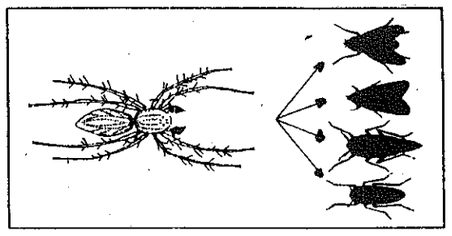
Characteristics of predators

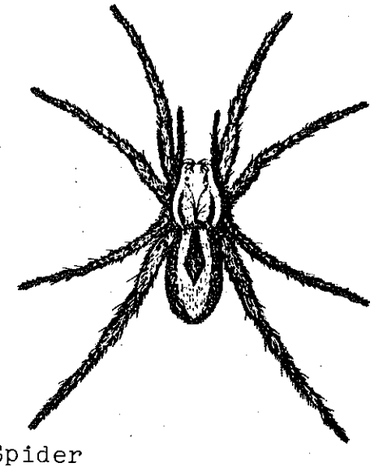
Most common predators of rice insect pests are other insects and spiders.



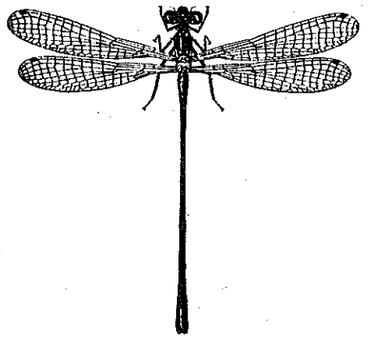




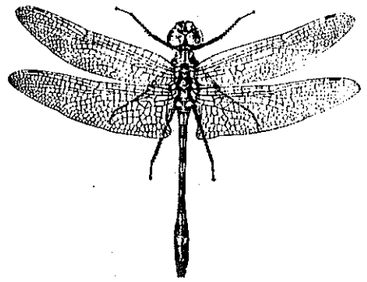




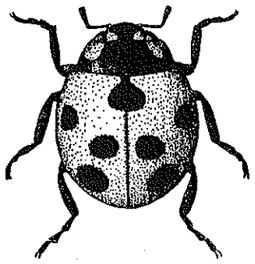
Spider
Predator of various insects



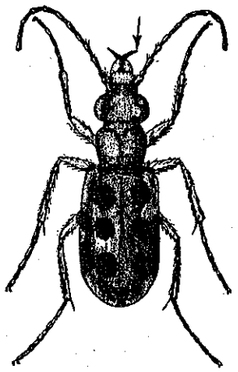
Damsel Fly
Predator of Brown Planthopper



Dragon Fly
Predator of Green Leafhopper



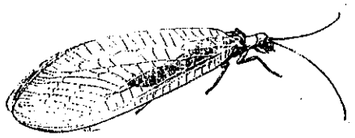
Ladybird Beetle
Predator of Leaf and Planthopper, Mealy Bug



Tiger Beetle
Predator of Rice Bug

Black bug
Predator of nymphs of Leaf- and Planthopper

Minute Wasp
Egg parasite of Stem Borer



Lacewing
Predator of eggs of moths and butterfly

FIGURE 55: Various predators of insect pests

UNIT 18
HARVESTING AND THRESHING

Harvesting

Rice is manually harvested by sickle 10 - 15 cm above the ground. Early harvesting brings a large percentage of immature and unfilled kernels and delayed harvesting reduces yield due to shattering and attack from birds, rats and insects. Timely harvesting ensures grain quality, a high market value and improved consumer's acceptance.

When to harvest rice:

1. When the moisture content of the grain reaches 20 percent to 24 percent before drying.

2. When 85 percent of the grains are straw-coloured, clear and firm.

3. When grains in the lower portion of the panicles are in the harddough stage.

4. Between 28 - 34 days after heading during the dry season and 34 - 38 days after heading during the wet (rainy) season.

Three components of loss during harvesting:

1. Shattering loss - premature seeding or separating of the rice grain from the panicle.

2. Lodging loss - sound and mature grains remain intact when plants fall. (Lodging may be caused by wind, rain or excessive use of nitrogen fertilizers).

3. Standing crop loss - standing crops with sound and mature grains are not harvested due to carelessness or haste.

Threshing

Threshing methods for rice vary greatly from place to place and season to season. The methods are generally classified as manual, animal, manual-cum-animal and mechanical.

1. Manual threshing: striking the bundles on the ground or on wooden planks or the bundles are beaten by sticks directly.

2. Manual-cum-animal threshing: the straw is laid in 2 - 3 layers and 5 - 11 bullocks are driven to move around on it until the straw is free from grains. This process ensures better quality straw for animal feed.

3. Mechanical

   a) By running the tractor over the layers of unthreshed straw.

   b) By threshing machines.

Factors affecting threshing

1. Moisture content of grain
2. Straw to grain ratio
3. Length of straw cut

4. Japanica varieties harder than the indica varieties
5. Operational skill

Cleaning or winnowing

Winnowing is done after threshing or after drying the grains. A layer of rice of about one inch is thrown on the floor by nanglo (flat tray of netted bamboo) and shaking or wind blowing is done by nanglo.

Drying

Rice is normally harvested at a point when the moisture content is 20 percent or more. Drying should begin within 12 hours but not later than 24 hours after harvesting. In general, 4 - 5 days of sun drying is required to reduce the grain moisture content to a level of 12 - 14%. This can be tested by biting one grain into two parts. If it is hard and splits immediately the moisture content is correct.

Two methods of sun-drying:

1. The harvested rice is placed in loose bundles and left to dry in the field for several days depending upon weather conditions, practices in the area and availability of labour.
2. Wet grains are spread on drying surfaces immediately after threshing. Concrete pavements, mats, plastic sheets, canvas etc. are used while drying rice grains.

UNIT 19
STORAGE OF RICE

U19.01 GENERAL

The main objectives of storing rice are to:

- minimize physical losses of grain
- maintain continuous supply of food
- serve a trading system
- maintain stable prices
- retain seed for planting in next season

Of all post-harvest activities like threshing, cleaning, transporting, storage of rice has been known to cause the greatest loss.

The post harvest losses of rice in Nepal are estimated to be 19%. Thus proper storage management plays a vital role in the agricultural economy.

Causes of damaged grain in store:

Primarily the seeds that are to be stored must be reduced in moisture content to a range of 12 to 14 percent wet basis (moisture content). The well dried seeds (12 to 14% m.c.) can be easily broken when tested by the teeth.

If seeds are stored without proper drying they are liable to get spoiled.

As we know grain is a living thing, it breathes like all other living things. Each kernel gets a little oxygen from the air and a small piece of food is burnt from its store house - the endosperm. This process gives off heat and carbon dioxide in the grain and is called respiration. Grain produces heat during respiration and if the stored grain has too much moisture in it, the respiration is faster. More heat is produced and hot spots are formed in the stored grain.

"Hot spots" are a sign that the grain has too high a humidity content and must be dried again because insects spread rapidly as the heat increases. Warm moist air generated from "Hot spots" caused by insects move upwards and condenses near cool surfaces (see Fig. 56). Thus the formation of moulds takes place on the upper layers of the grain.

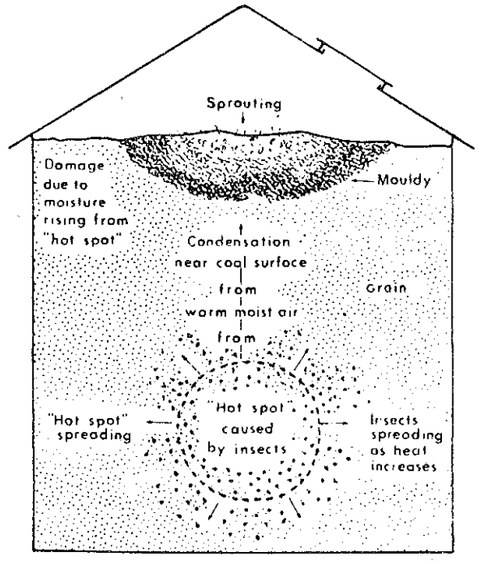


FIGURE 56: Spoilage of grain due to temperature gradients, movement of moisture and localized development of fungi and insects.

U19.02 FACTORS AFFECTING STORAGE OF GRAINS:

Moisture content of the grain:

Moisture is the most important factor bringing about harmful changes during storage. For safe storage, the moisture content of the paddy rice should be 12 - 14% by wet basis.

Moisture in the air:

There is a relationship between the moisture content of the grain and the relative humidity of the air. The grain releases moisture into the air or absorbs it until a certain equilibrium has been reached. This state is called equilibrium moisture content.

Grain that is not sealed in a closed container will continue to exchange moisture in the air. During the rainy season for example, grain will take on moisture if left in an open container and in the hot, dry season, grain will lose the moisture again. The drying process can be positively influenced by controlled ventilation.

Temperature:

The temperature of the air outside the storage container and the temperature of the grain inside the storage container affects storage conditions. Grains placed into storage should be as dry and as cool as possible in order to preserve the quality because:

- a low temperature is better than high temperature for grain storage. Insects and mould do not grow as much at low temperatures.

- grain breathes very slowly at low temperatures.
- rising temperatures outside the container can increase the temperature inside the container especially if the container is not in a shaded spot.
- rising temperatures can lead to insects and mould growth.
- hot spots can form in areas of the grain where the most mould and insect activity occurs.

Grain conditions

Only clean and healthy grains which have been dried to safe storage levels (12 - 14% M.C.) must be stored.

Container conditions:

The container, whether it is a warehouse, a bin or sacks must be clean and free from insects, dust, spillage and old grain residues.

Store surroundings:

The surroundings of the store should be equally clean and free from insects and pests.

U19.03 METHODS OF STORAGE

(I) In sacks
(II) Loose in bulk

The choice of method depends upon the following factors:

a. The geography of the area (average rainfall, temperature, wind velocity, type of soil on which storage facilities are to be built).

b. Type of grain and its use

c. Quantity of grain to be stored

d. Duration of storage

e. Transport system

f. Cost and availability of sacks

g. Cost and availability of labour

h. Incidence of rodents and certain types of insects

Guidelines for good storage practices:

- dry grain well before putting it into storage
- clean the container or warehouse well before storing new grains
- put only clean grain (free from dust, old pieces of grain, dirt, etc.) into container
- remove split and broken sacks
- keep the grain cool by protecting the container from changes in the outside temperature
- protect the grain from insects by applying insecticide or by putting the grain into air tight storage facilities
- keep the warehouse and containers water proof
- keept container rodent-proofed in all possible ways
- periodically check the grain.

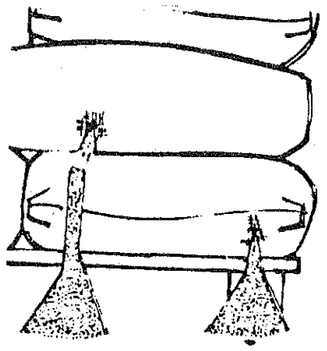


FIGURE 57: Look for split and broken sacks

Regular check-ups of stored grain:

Regular check-ups must be done for stored grain in order to check the following factors:

a. Chemical changes in grains

b. Growth of micro organism on grains

c. Development of insects and mites on grains

d. Rodents feeding on grains

e. Mishandling of grains affecting the quality and causing loss through spillage

f. Damage of containers (bags) and leaking roofs

g. Exposure of products to extremes of temperature and moisture

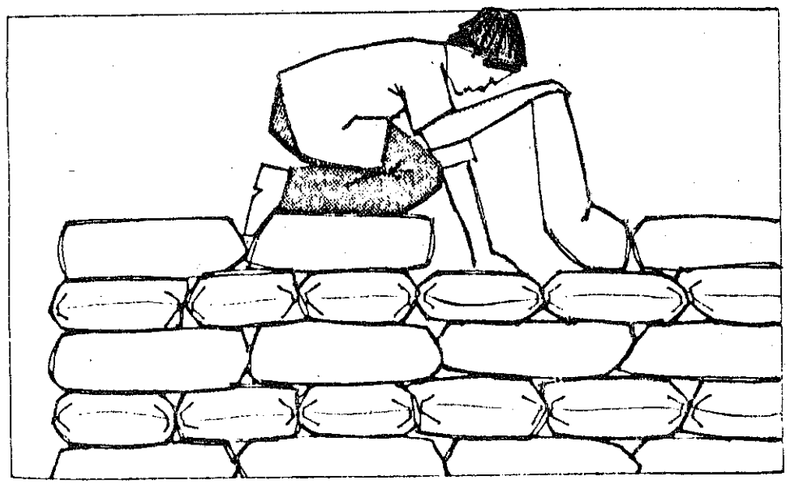


FIGURE 58: Lifting a top bag and feeling the bag beneath for heating

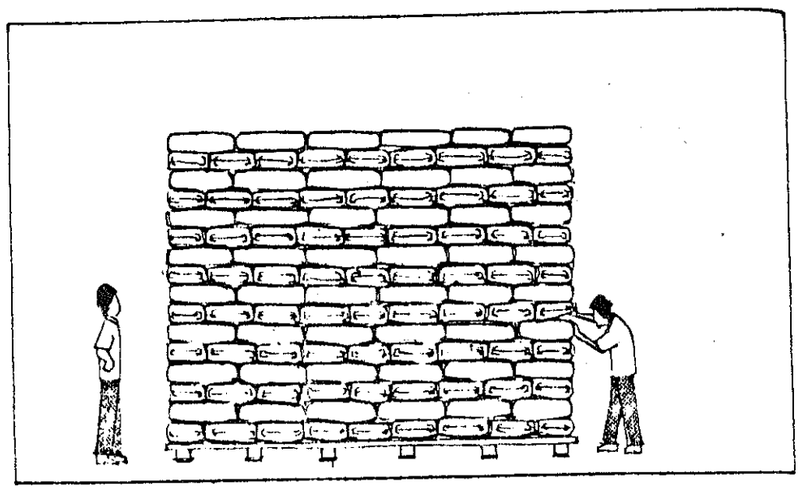


FIGURE 59: Inspect all around the sides of a stack

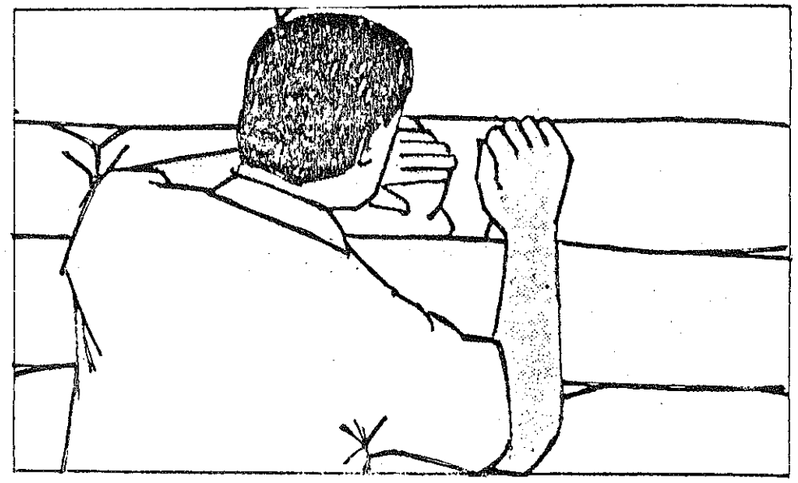


FIGURE 60: Look between bags. In the seams and "ears" of bags for insects

Storage losses:

Losses can be noticed in one or several forms as follows:

a. Weight loss: The reduction in weight due to insects, rodents, or birds feeding themselves or from spillage.

The average physical weight loss for paddy in Nepal is 4.14% in the mountains, 5.5% in the hills and 6.7% in the terai. The average loss for Nepal as a whole is 6.2%.

The loss due to rodents is high among the biological agents. The estimated figures for loss due to rodents is 2.5% in the mountains, 3% in the hills and 4.1% in the terai.

The loss due to insects are estimated to be 1.6% in the mountains, 2.5% in the hills and 2.6% in the terai.

Region	Rodents	Insects	Mould	Total
Mountain	2.5	1.6	0.04	4.14
Hill	3.0	2.5	0.05	5.55
Terai	4.1	2.6	-	6.7
Nepal	3.2	2.2	0.04	5.5

TABLE 19: Percentage loss on storage of paddy in all structures

b. Nutritional loss: It is the loss in terms of nutritional value to the human population concerned.

c. Quality loss: It is assessed on the basis of appearance (colour, shape, size and foreign matter such as weed seeds, stones, parts of plants, etc).

d. Monetary loss: When farmers cannot store their paddy and sell it at a lower rate.

e. Loss of quality: This occurs due to poor storage practices.

f. Loss of seed viability: This is measured on the percentage of seed germination.

U19.04 STRUCTURES FOR RICE STORAGE

1. Traditional methods:

Heap storage:

The paddy is heaped on wooden platforms inside the house and covered with straw mats.

Advantage:
- this method is good for a short period
- there is no additional expense for sacks or bins.

Disadvantage:
- this method cannot be used for a longer period
- the percentage of loss by rodents is maximum

Plant or bamboo structure:

Mat bin (Bhakari). This is constructed of plant materials especially from bamboo. It is raised from the ground and the top is covered with straw and cowdung. It is also called "Chitrako Bhakari" locally. The other materials that are used to make the bins are reed and peagion pea dried plants. It is usually cylindrical in shape and is kept inside the house. "Chitroko Bhakari" is very popular in the mountains and hills. About 80% of the farmers in the mountains use this structure to store paddy for about 8 months. Similarly it is also used by about 60% of the farmers in the hills to store paddy for about 9 months.

The capacity of the bin varies from 1 to 14 quintals (2 to 28 muri).

Advantage: - Mat bins can be made from local materials
- the initial costs are low

Disadvantage: - It is not rodent proof

Basket:

Baskets made of reeds and bamboos are also used to store grain in small quantities.

Earthen structures:

Mud bins (dehari):

Mud bins is the most common indigeneous type of indoor structure usually found in the terai where it is popularly known as "Dehari". Paddy chaff, husk and cowdung are mixed with soil and the desired shape is made. The bin is kept on a raised platform supported either by wooden poles or brick masonary pillars. In the terai about 65% of the farmers use this structure to store paddy for about 9 months. The average capacity of the structure generally used by the farmers ranges from 1 to 6 quintals (2 to 12 muri).

Advantage: - The bin can be made locally
- initial cost is low

Disadvantage:- It is not rodent proof

Burnt clay pots (Ghampo and Gagro):

Burnt clay pots of different shapes and sizes are used for storing the paddy. It is popular in the hill and in the

mountains, too. The pot most commonly used by a large number of farmers has a storage capacity of 25 to 50 kg (½ to 1 muri).

Advantage: - It can be locally made by potters
- It can last for many years if properly handled

Disadvantage: - It is not moisture proof
- It is breakable

Average percentage loss of all grain stored in various structures are shown in Table 20.

Structure	Average percentage loss for all grains		
	Mountains	Hills	Terai
Dehari	-	2.6	6.9
Chitrako Bhakari	5.6	7.0	10.4
Thankro	9.1	7.4	7.9
Berry	-	8.4	3.8
Kathko Bhakari	-	3.0	6.0
Dhikuti	4.4	5.5	-
Gagro	4.1	7.1	-
Thunse	6.0	4.7	-

TABLE 20: Percentage loss in various structures

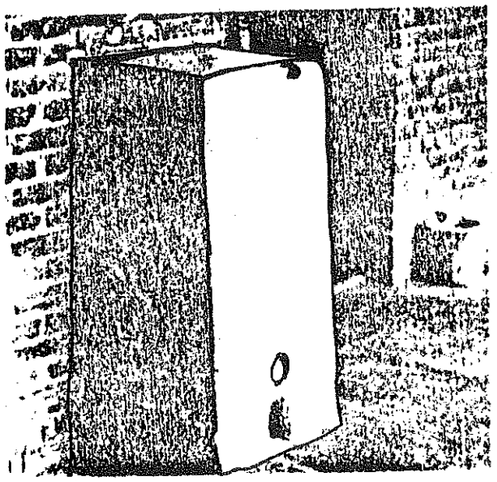
2. Improved structure:

Pusa bin:

A pusa bin is a simple improved rectangular mud structure with a polythene sheet in between the wall. It can hold 2000 kilogrammes (40 muri) of grain for more than a year.

Materials for construction:

- mud or about 750 unburnt bricks
- polythene sheet, 9 metre (180 cm wide, 700 gauge)
- galvanised tin sheet pipe 24 cm long (9 cm Ø)



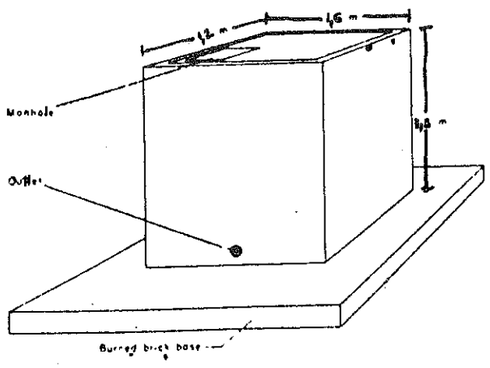


FIGURE 61: Pusa bin incorporating plastic film sheeting in mud wall construction, together with two constructional diagrams.

capacity: 2,000 kg (40 muri)

Size: 1.4 m x 1.0 m x 1.6 m high
(internal dimensions)

Construction details

Walls:

Four walls consist of two layers (each 7.6 cm) of mud or unburnt bricks with a polythene film sandwiched inbetween.

Floor and roof:

Consists of two layers (each 5 cm) of mud with a polythene film sandwiched inbetween. A wooden frame is used on top to form the mud roof.

Manhole:

Placed in one corner of the top surface measuring 60 cm x 60 cm.

When the bin is filled with paddy the manhole is finally sealed with a square piece of polythene film and sealed with mud.

Outlet:

24 cm length galvanised tin sheet pipe (9 cm Ø)

The structure can be improved by covering with a thatched roof with plenty of overhang to keep the surface of the structure as cool as possible.

Split bamboo bin (Chitra Ko Bhakari):

This is an ordinary bin made out of split bamboo. In the improved bin a metal plate of about 50 cm in height is provided in the lower portion of the structure. A metal cover on the top is also provided to make it rodent proof. In some bins, a sloping outlet (3 inch Ø metal pipe with cover) is attached at a height of 10 cm from the bottom. The purpose of providing an outlet is to take the grains out easily.

3. Modern methods:

Metal bin:

Cylindrical shaped metal bins are available for storing upto 1000 kg of grains.

Advantage:
- It is transportable from one place to another
- It is rodent proof
- It is very effective for fumigation
- It lasts for many years.

Disadvantage:
- It is expensive

Warehouse:

Grains are stored in the warehouse either in bulk or in bags.

Types of storage methods

1. Bag storage is suitable in areas having
   a) Poor road and transport facilities.
   b) Small quantities of grains delivered and handled.
   c) Different varieties of products to be handled.

2. Bulk storage is suitable in areas where:
   a) Types of varieties handled at any time are small.
   b) Power available for mechanization.
   c) Good road facility for trucks.
   d) Only one type of grain is handled throughout the year.

Design of stores for bag storage:

Buildings designed for safe storage of grains should have the following criteria:

1. The building's long axis must be oriented east-west wherever possible in order to reduce the heating action of the sun. The roof must not leak.

2. Provision of air for fumigation of entire contents.

3. Fitted with controllable ventilation.

4. Doors and ventilators must be proofed against entry of rodents and birds.

5. Free of holes and corners where dust and residues may lodge.

6. Roof without any light-transmitting areas in order to avoid high temperature areas on top of stored produce.

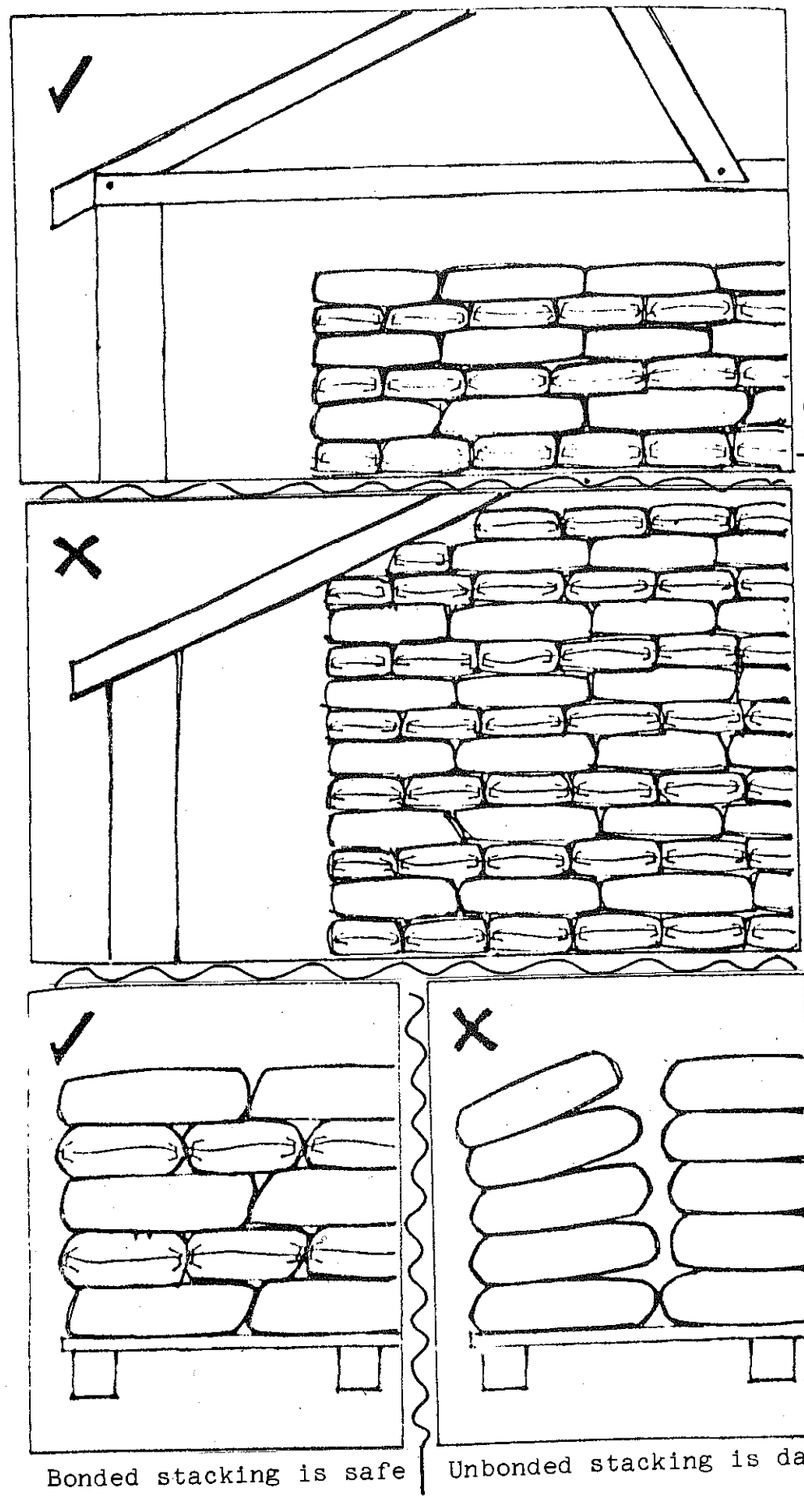


FIGURE 62: How to store the sacks

Important factors when storing bags are illustrated in Figure 62.

Tips for handling bags:

1. While unloading, see that the bags are not
   a. torn and spilling grains.
   b. wet from condensation or rain.
   c. infested on the surface with insect pests.

2. Keep aside the defective sacks for repair, drying and fumigation. Do not put it into the main stack.

3. Repair damaged bags as soon as possible.

4. Handle all the sacks carefully to avoid spillage. Do not drag or drop the sacks.

5. Do not carry or unload the sacks when it is raining.

Maintenance of the godown:

Godown must be kept clean to

- Discourage insects and pests.
- Make inspection easier.

Routine godown cleaning procedures

- When a godown is in daily operation, it should be swept regularly to remove all dust and grain residues from the floor.

- When not in daily use, godown floors should be swept at least once a week.
- Walls and sides of stacks should be swept weekly. If insecticide has been sprayed recently, sweeping operations should be postponed until the following week.
- Window ledges and roof beams should be swept regularly to remove all dust and grain residues.
- Always clean the upper parts of the store first and clean through the door.

UNIT 20
STORAGE PESTS OF RICE

The main pests causing deterioration of stored rice are

- insects
- fungi (moulds)
- rodents

U20.01 INSECTS

Among the insects, grain moth, rice and maize weevil, and lesser grain borer are recognized as major insect pests of stored rice. Besides these insects, other insect pests are also seen in the stored rice but they seem to be insignificant and unimportant in terms of damage.

Grain Moth

Scientific Name: Sitotroga cerealella

Nepali Name: Anajko Putali

It is a very important primary pest of rice and is distributed throughout the country.

Identification: The adult is a small (8-10 mm) straw coloured moth, sometimes with a small black spot on the forewing. The wings are narrow and fringed with bristles (Fig. 63).

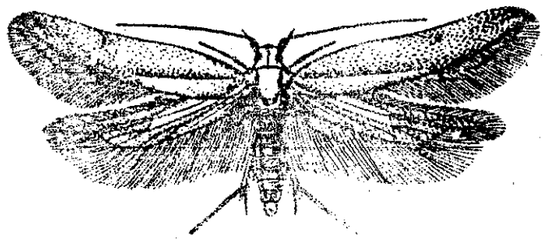


FIGURE 63: Grain Moth

Damage: The developing larvae cause all damage, as the adult do not feed. It can infest rice before it is harvested. In the bulk stored grain, it is abundant in the surface layers (about 30 cm depth) only.

Life History: The female lays eggs on the surface of the grain (about 100 eggs per female) in the field or storage. The larva hatches and bores its way into the grain where it remains until fully grown. The larva eats a channel to the surface leaving a thin layer of the seed coat, before it pupates. After pupal stage, adult pushes open the thin area prepared by the larva. The life cycle completes in about five weeks. There can be 4 - 5 generations per year.

Rice Weevil

Scientific Name: Sitophilus oryzae

Maize Weevil

Scientific Name: Sitophilus zeamais

Nepali Name: Ghun (for both species)

These pests are common throughout the country and most destructive pests of stored, especially, milled rice.

Identification: These two pests are distinguishable from all other common storage pests by the long beak (snout) which is characteristic of all weevils. The adult is 2.5 to 4 mm long, dark brown and sometimes with four lighter spots on the wing (Fig. 64). The larva is legless and has a characteristic curved appearance.

Damage: Both species can fly and thus infest rice in the field before harvest. These species are not true primary pests of paddy, because the female cannot penetrate sound husks and thus requires gross husk defects before it can penetrate. The larvae develop and feed inside the grain and are responsible for most of the damage. Moisture content of the rice grain plays a vital role for the attack of these pests.

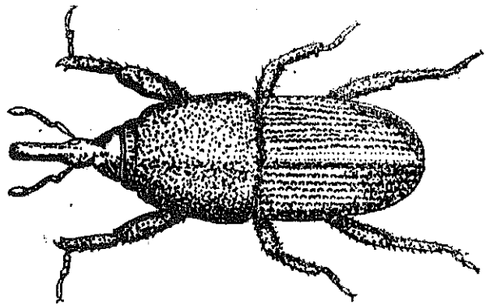


FIGURE 64: Rice Weevil

Life History: The eggs are laid inside the rice grain by the female (capable of laying 300 to 400 eggs) which chews a minute hole to lay each egg; this is followed by sealing the egg in the hole with a secretion. The larva hatches and remains inside the grain where it feeds; it develops into the

nonfeeding pupal stage and then into the adult which bites its way out of the grain, leaving behind an emergence hole. The life cycle of these pests is completed within 5 weeks under optimum conditions. There can be several generations in a year. Adults live for about five months.

Lesser Grain Borer

Scientific Name: Rhizoportha dominica

This insect is also a primary pest of sound dry cereal grain and prevalent throughout the country.

Identification: This brown beetle is only about 3 mm long. It has a prominent rounded thorax with the head turned down under the thorax so that it is invisible from above (Fig.65).

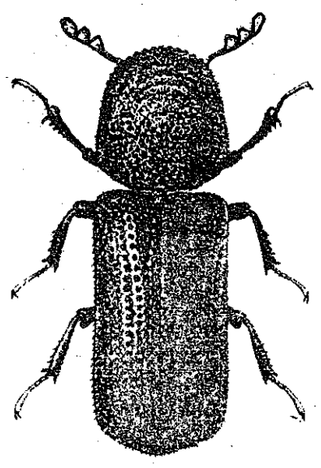


FIGURE 65: Lesser Grain Borer

Damage: Both the adults and the larvae of this insect bore holes in the grain and leave behind a powder from the chewed-up grain. They can also attack sorghum, maize and wheat.

Life History: Eggs are laid on the surface or in the interstices between grains. A female is capable of laying 300 to 500 eggs. The larva emerges and eats its way into a grain where it feeds unselectively. When fully grown, the larva pupates inside the grain and the adult emerges from it. Under warm conditions (30 °C to 38 °C) its life cycle is completed within 5 weeks. It can have five generations per year.

U20.02 CONTROL OF INSECTS

A. Control of insects without insecticides

1. Dry the grain well (moisture content should be below 14%).

2. Clean the grain well.

3. Keep stored grain or grain containers out of strong sunlight. This will keep the grain cooler. Warm grain will breed more insects.

4. Keep stored grain containers in places where winds can help to cool the containers.

5. Store grain away from wet areas.

6. Protect the stored grain from rain and run-off water.

7. Make sure the storage area is clean. Sweep the walls, ceilings and floors and get out all dirts, old grains and dust before putting new grain in.

8. Put only whole, healthy grains into storage. Do not store broken grains.

9. Do not mix new grain with old one. Old grains that must be kept should be thoroughly fumigated.

10. If possible, place grain into special containers (e.g. metal or concrete bin) which can be sealed tightly.

11. Make sure that the sacks filled with grain are not attached to walls or placed directly on the floor. Moisture from the wall and the floor will dampen the grain. Pallets or dunnage can be used to form a barrier against damp (from floor). Sacks should be placed at least 1.0 m away from walls.

12. Check grain regularly.

13. Watch for flying weevils in the early morning or late afternoon.

14. Watch for moths any time of day.

15. Hit a sack against the floor. Then let it rest out of direct sunlight for a while. Then check to see if there are any weevils on the outside of the sack.

16. Dump part of the grain out or take some out from the middle of the storage containers.

17. Put the grain through a sieve.

18. If a large number of insects is present, dump all the grain out on a plastic sheet or tarpaulin under the hot sun. Do not put the grain directly on the ground.

Or put all the grain through a sieve and remove the insects. Burn the insects so they cannot return to the grain.

19. Mix grain with clean sand or clean wood/cowdung ash. Sand and ash damage the insects bodies and they die. However, it is usually restricted to the storage of small quantities in earthenware pots or tin can for seed/food purposes.

20. It is believed that in many areas certain local plants (eg neem) have a repellent effect upon insects and that when they are mixed with grains in storage some control of infestation is achieved. Thus, find someone, who knows about such practices and ask for detailed instructions.

21. Disinfect jute sacks by dipping in boiled water then dry in the hot sun.

22. Large storage structures (warehouse/godown) usually require chemical treatment and small rural structures can be cleaned by using smoke and making use of the sun and rain. After sometime insects will usually leave a clean storage structure.

B. Control of insects with insecticide

If there is continued trouble get advice from someone who knows about insecticides that can be used against the insect pests.

Generally, methods of using insecticides on stored products are:

Dusting: Dilute dust formulations are used in each layer of bags during construction of a bag stack. Dust treatments may be successfully on the top surface but most inefficient on the sides of stacks because it is not possible to get good coverage. Dilute dusts can also be used as a band of dust around a stack of produce, for example to prevent crawling insects attacking it. Dilute dusts are also used for admixture with seeds. Insecticide recommended is 5% malathion dust at the rate of 10 g per sack or 20 g per square meter. For seed purpose, malathion can be mixed with the grain at the rate of 2 g per kilogram of seed. As other insecticides, 10% lidane dust can be also mixed with grain, if it is only for seed purpose, at the rate of 1 g per kg of grain.

Remember: Grains directly mixed with insecticide should be used only for seed purpose not for human consumption and livestock feeding.

Spraying:

Application of sprays differ with the type of storage facility used. In warehouse/godown, the following procedures are used:

Treatment of bag stacks: Each layer of bags is sprayed as the stack is built. This provides protection for several months. In case of reinfestation, the stack should be sprayed and fumigated for effective penetration. The external stack treatment usually consists of a spray application to the four sides and the top surface of a bag stack. Bag stacks will particularly require surface spraying when they are in a store containing other produce which is infested or in areas where infestation from external sources is high. The insecticides most commonly used for this purpose are malathion (cythion), fenitrothion (sumithion, folithion) and pirimiphos-methyl(actellic).

Recommended rate:

(a) Malathion. 400 g of 25% wettable powder or 200 ml of 50% emulsifiable concentrate, in 5 litres of water per 100 square metres.

(b) Fenitrothion. 50 g of 50% wettable powder or 50 ml of 50% emulsifiable concentrate, in 5 litres of water per 100 square metres.

(c) Pirimiphos-methyl. 50 ml of 50% emulsifiable concentrate in 5 litres of water per 100 square metres.

The wettable powder formulations are preferable to emulsifiable concentrates for application of jute bag stacks: this is because the emulsified insecticides may be largely absorbed by jute bags and may contaminate food grains. With wettable powders, the particles of powder, which contain the insecticide, are filtered out on the surface of the jute bags and become effective on insects.

While spraying, the distance between the surface of the jute bags and the nozzle should be 0.5 metre.

For spraying wettable powders, if possible, use knap sack sprayer with stirrer system. This prevents accumulations of insecticides at the bottom of the sprayer tank.

Residual spraying of storage buildings and structures:

Before spraying the stores and bins should be cleaned thoroughly. Malathion, fenitrothion or actellic, at the rate recommended earlier for stack treatment, can be used to spray all internal surfaces including floor and roof. The wettable powder formulations are preferable to emulsifiable concentrates for applica-

tion to cement, brick, stone or white washed (with lime) surfaces. This is because emulsified insecticides are largely absorbed into cement and stone work and do not remain on the surface the insects are in contact with. With wettable powders, the particles of powder which contain the insecticide, are filtered out on the surface of the cement, the water being absorbed into the wall. Treatment should be carried out at intervals of 3 weeks.

Residual spraying of malathion on cement or white washed walls (alkaline condition) is less effective because it is unstable.

Remember: Without store hygiene insecticides are ineffective and uneconomical.

Space Spraying Treatments

It may be necessary to use space spraying techniques to control infestations of flying pests (grain moth) entering from outside.

A non-persistent insecticide like Nuvan 100 EC is sprayed for this purpose. The recommended rate of this insecticide is 10 ml of Nuvan 100 EC in 1 litre of water per 250 cubic metre.

This treatment should be carried out at least three times a week and also at a time of day when the pests are most active, generally at dusk. It is necessary to close door and ventilators, etc. and keep them closed for an hour or two after treatment.

Remember: Nuvan 100 EC is highly toxic to man and therefore great care must be taken.

Fumigation

Chemicals used to fight insects through their respiratory system are known as fumigants. These chemicals are able to penetrate a stack of bagged grain or bulk grain stored in a container and thus kill any infestation present (including eggs and other immature stages inside the grains). However, these chemicals will not give lasting protection against reinfestation or reinvasion of insects. Therefore it is necessary to carry out a surface spraying of stack as well as residual spraying of the walls, roof and the floor.

Among the fumigants, only Phosphine (PH_3 hydrogen phosphide) is marketed in Nepal, as Celphos, Phostoxin, Phosfume or Quickphos tablets. It is an excellent fumigant and fairly easy to use. When the tablet is exposed to the air, it interacts with moisture and temperature, and releases phosphine gas, which is toxic to insects as well as human beings.

The tablets are formulated in a way that there are about 30 minutes available to distribute these tablets before the phosphine gas is released. The gas has a strong and unpleasant smell (rotten fish) and is therefore easy to detect. Phosphine does not interfere with germination if the grain is to be used for seed.

This fumigant is recommended at the following rates:

For fumigation under fumigation sheet (tarpaulin, plastic sheet etc): 3 tablets per metric ton (1000 kg) of stored seed/grain or 2 tablets per cubic metre (m^3) of bag stack/storage bin.

For space fumigation inside warehouse:
2 tablets per cubic metre of storage volume.

Generally space fumigation of a warehouse or godown is uneconomical. In Nepal most warehouses or godowns are not

suitable for this kind of fumigation because complete sealing cannot be achieved.

Exposure Period: Depends on temperature and moisture of grain as well as grain storage structure. However, at least 3 days during summer and 8 days during winter is generally recommended. More than 8 days is not advisable.

Application of Phosphine Gas

1. Make sure that the storage structures or bag stack can be sealed perfectly.

2. Determine the quantity of grain or volume of stack to be fumigated.

3. Compute the number of phosphine tablets required.

4. Distribute tablets in the stacks or bins evenly.

5. Use cardboards and avoid contact among the tablets for the stack fumigation whereas loose wrapping of individual tablets is recommended for the fumigation of bulked grain in bins.

6. Make sure that gas-proof tarpaulin or plastic sheet is properly sealed to the floor by using sand snakes. For the bins use tight fitting lid and seal them completely by any means (using adhesive tapes, paper and glue, or any other local means).

7. Fix a warning sign with the date of application and lock the store house.

8. Wait until exposure period is over (3 days during hot summer and 8 days during extreme winter).

9. Before lifting the tarpaulin / plastic sheet or cover of the bins, open all the doors windows and ventilators.

10. Lift the tarpaulin/plastic sheet or cover at the corners and leave it for at least one hour to allow gas to escape. Do not allow anybody to enter at this time.

11. Remove the tarpaulin/plastic sheet or cover of the bin completely and aerate for at least 6 hours.

12. If possible, check the gas concentration. In the absence of gas detector: the gas (phosphine) has an unpleasant (rotten fish) smell and if the smell is very strong wait until it is almost not smelling.

13. Before consumption the grains should be first sun dried. This helps to remove the remaining unpleasant smell.

Precautions:

1. If possible, wear fullface gas mask with filter type B 900 (grey colour).

2. Never work alone during fumigation.

3. Make sure that nobody is sleeping in neighbouring rooms.

4. Never place a large number of tablets in one place to avoid poor decomposition or even explosion.

5. Do not smoke or eat during the application.

6. Wear gloves and avoid touching the tablets with bare hands.

7. Wash hands after application.

8. Keep tablets and empty containers out of reach of unauthorized persons.

9. Check the tightness of the tarpaulin and mend it if necessary.

U20.03 FUNGI (MOULDS)

Field fungi, such as Fusarium and Helminthosporium are known to attack rice grains before harvest. They survive in the seed and may continue growing during storage. The fungi develop only on seeds/grains with a high moisture content (22 - 25%).

Mouldy products should not be used for human or animal consumption

Control:
The primary cause of fungal deterioration of stored products is the presence of excessive moisture and warm storage temperature. Therefore, drying grain well (with moisture percentage below 14%) and storing them in a cool place (if possible, below 25 °C) is the best method of controlling storage fungi.

U20.04 RODENTS

Rodents cause food loss by consuming grains and by contaminating (with their faeces, urine, body hairs or ectoparasites) far more (10 - 20 times) than they consume. They spread diseases such as plague, jaundice fever, rickettsia which are transmittable to man. See Fig. 66 to know what else rats can do.

The three important rodent species which are commonly found in Nepal are: Rattus rattus (black rat, roof rat, ship rat, or Alexandrine rat), Rattus norregicus (brown rat, common rat, sewer rat, or Norway rat) and Mus musculus (house mouse). Their diagnostic signs are given in Table 21.

General habits and characteristics of stored grain rodents

Knowledge of the habits of rats and mouse is important for establishing effective and economic control measures. Fortunately, if the farmer understands how rats and mice live and if he knows what rodents will and will not do, there are many things he can do to fight rodents.

- Rats and mice are very clever and suspicious, meaning they will avoid unfamiliar objects such as traps or poisoned bait, particularly if they are laid down for the first time.

- They are colour blind and have poor vision, but the sense of taste, smell, hearing and touch are highly developed. They use their body hair and whiskers to touch with.

- They are good swimmers and not afraid of water.

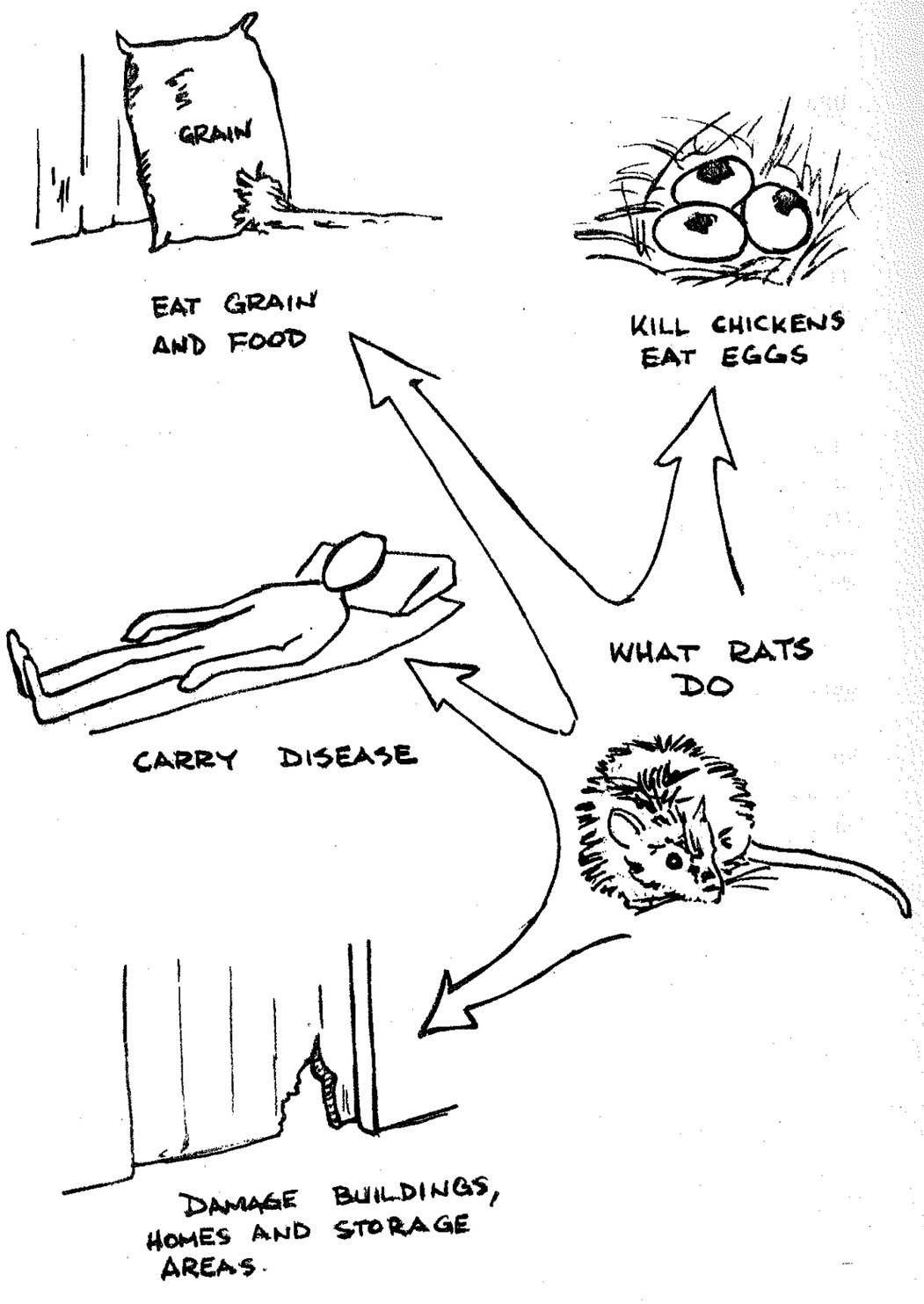


FIGURE 66: What Rats do

- They can climb walk of concrete, perpendicular pipes, wires and trees. Rats can reach about 32 cm up a wall and can do a standing jump of almost 60 cm. They can do a running jump as high as 90 cm. Even a mouse can do a running jump of 60 cm. A mouse can enter from small holes (up to 1 cm diameter).

- Rats and mice usually do the same things every day at the same time. They are most active from sunset until about midnight. They also move around at certain other hours during the day and night. If grain is stored in a dark, cool place as well as in unhygienical conditions they will go in at any time of day.

- Rodents always use the same path. When a rodent is going from its nest to eat grain it always goes along the same path. It chooses its path in a way it will be running beside walls or stacks. It remains out of sight as far as possible. If the food is out in an open space, the rodent quickly grabs it and runs back to its path.

- Rats and mice live close to food and water. The roof rat likes to nest in ceilings, but the common rat or brown rat digs under the ground. Rats dig down along a wall. If something blocks the digging, they stop.

- Rodents must use their teeth. The front teeth grow until the rodent dies. The teeth are growing 10 - 12 cm a year. Rats must gnaw things all the time to keep the size of their theeth down.

- Rodents like some food more than others. Some of the food they like is meat, grain, eggs and potatoes.

- A female rodent is able to produce 3 - 12 young ones in a litter and per year there can be 3 - 8 litters. Under optimum conditions litters are produced every 3 weeks and the young mature between 1 - 3 months.

- On an average a rodent lives for one year, but under laboratory condition it can survive up to 3 years.

	Rattus rattus	Rattus norvegicus*	Mus musculus
Adult weight	150-250 grams	150-400 grams	15-30 grams
Tail length	Longer than body + head	Shorter than body + head	Longer than body + head (or equal)
Ears	Thin, translucent, large, hairless	Thick, opaque, short with fine hairs	Large, some hairs
Snout	Pointed	Blunt	Pointed
Colour	Grey, black or brown may have white belly	Brownish grey, but may be black, grey belly	Variable brownish grey
Droppings	In groups, but sometimes scattered, spindle shaped	Scattered, banana shaped	Scattered, thin both ends rounded slightly curved

TABLE 21: Diagnostic signs of three rodent species

* Rattus norvegicus is of less importance in Nepal

Clues to the presence of rats and mice

1. droppings
2. loose earth from burrowings
3. footprints on dusty floors
4. greasy marks on set routes of travel, e.g. on beams
5. holed sack with grain leaking
6. gnawing damage to building fabric

Control of rodents without chemicals (rodenticides)

The three most important things one should do to control rats and mice without using poison are as follows:

(a) Keept the farm and storage area as clean as possible:

1. Do not pile food or trash around the outside or inside farm buildings.
2. Bury or burn all garbage and old food away from the house and storage place.
3. Place all food items in covered containers.
4. Store grain sacks off the floor.
5. Sweep out all dirt, dust, straw, old cloth that rodents might nest and hide in.
6. Cover dirt floor with a thin layer of mortar. This keeps rats from digging through the floors.
7. Keep the grass cut short around all farm buildings. Rodents like to hide in grasses.

8. Cut all tree branches, which touch windows, and roofs to keep rats from climbing the trees and jumping in through the windows and roofs.

(b) Rodent proofing (see Fig. 67)

1. Local mud bins are generally rodent proof to some degree, particularly if they are kept off the ground.

2. Place storage bin at least 1 m above the ground, because most rodents can jump up to 90 cm high.

3. Put barriers (rat baffles or rat guards) on the legs of the storage bin so that rodent cannot climb.

4. Never keep a ladder, bicycle or other equipments near storage places. Rodents use such items to climb in order to reach stored grain.

5. Construct storage building on structure on a concrete base of at least 50 cm height. The floor should also be concrete. If the bin is made of tin sheet, the sheet should be fixed in concrete. Place sheet of metal bands (40 cm high) around mud or bamboo bin or cement silos to prevent rodents from climbing and gnawing.

6. Make sure doors and grain chutes fit tightly. A wooden door should have a thick metal sheet along the bottom to stop rodents from eating through.

7. Cover all the windows and large openings with heavy wire netting.

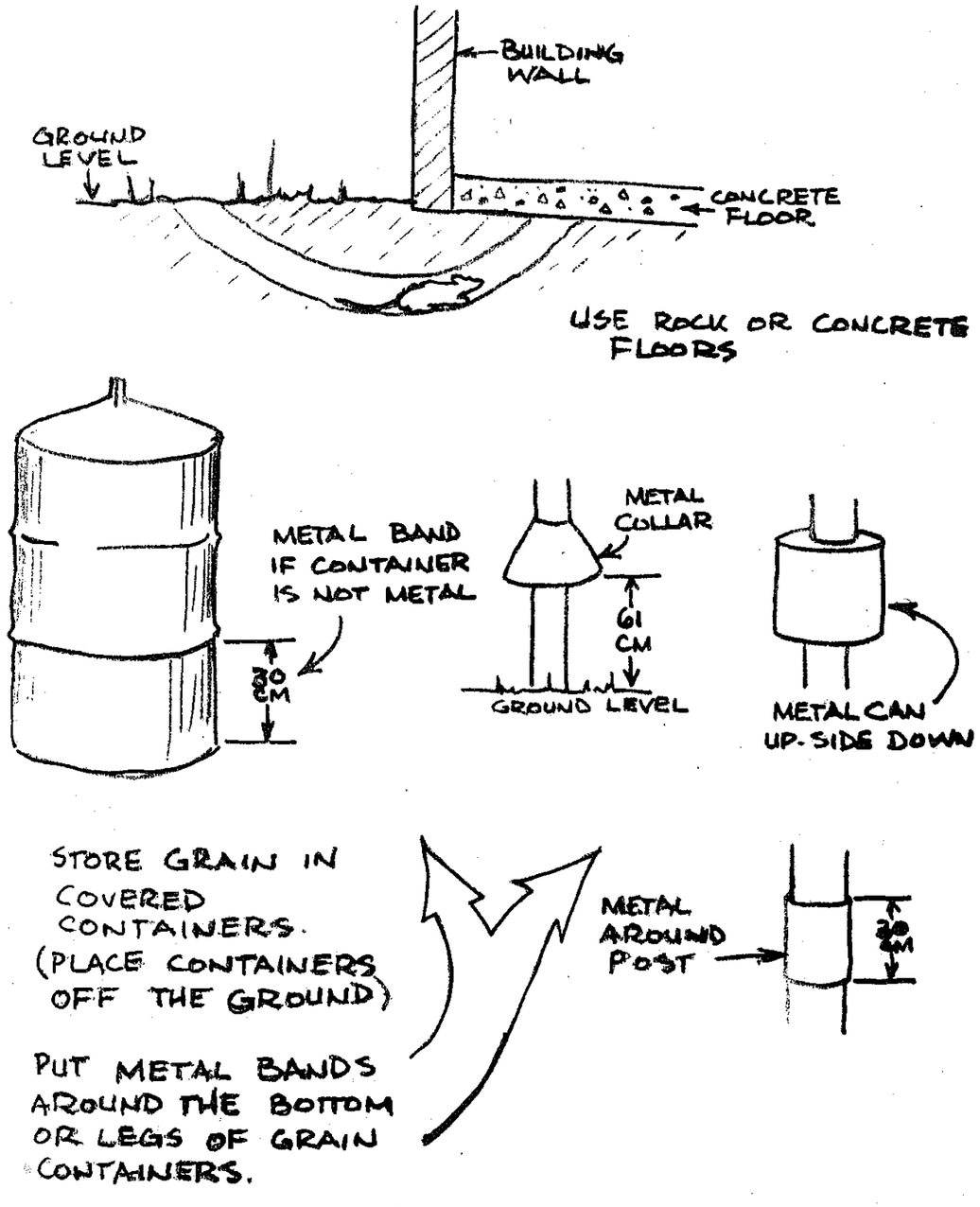


FIGURE 67: Rodent-Proofing

8. Holes in a roof made of corrugated tin should be filled with cement.

9. Cover the ends of any pipes which enter the building where grain is stored with wire netting.

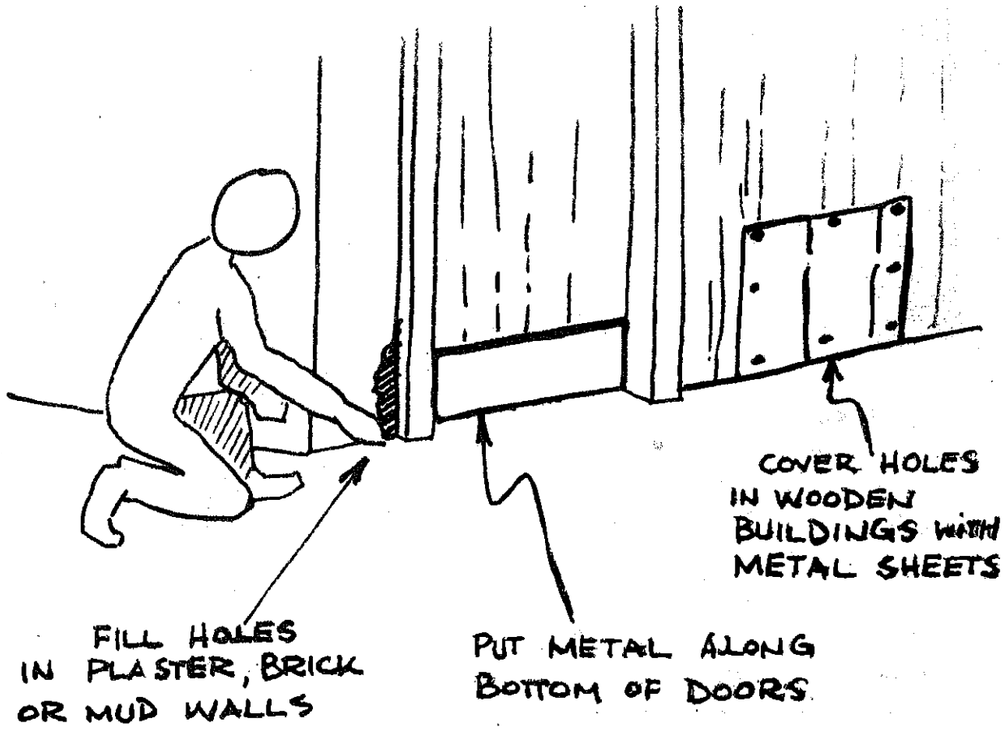


FIGURE 68: Rodent-proofing of godowns

(c) Setting traps

Traps can be very effective if correctly placed and used. They need to be regularly maintained. They may be used in places where poison is hard to get. Traps are also much safer in places very near to stored grain, in houses and storage buildings. However, trapping is generally only suitable for controlling small infestations. In order to achieve an appreciable degree of control over large infestations, it is necessary to use high trap density and the initial cost of the traps or the labour involved in setting them may make this method uneconomic.

There can be different types of traps which can be purchased or prepared locally. Some of the traps which are commonly used are as follows:

1. Pot trap: Consists of a clay pot or petrol drum partially filled with water, over which a maize cob (or any suitable bait) is suspended as bait. A provision is made, so that rats can reach for the cob with jumping. As the rat reaches the cob, it turns causing the rat to loose its balance and fall into the pot.

2. Steel trap: This trap has a base with a trigger and two steel jaws. When a rat steps inside and releases the trigger, the jaws snap together and the rodents are caught and farmers have to kill the rats.

3. Snap trap: This has a flat wooden base. It kills with a heavy wire which is pulled back by a spring. When a rat or a mouse touches the trigger, the wire comes down over the rat, breaking its back.

4. Box/cage trap: It is placed on paths and other places where rats and mice have been observed. It is operated with or without spring. A rat or mouse is trapped inside the cage or box.

Placing the traps

1. Place baited traps very near the rodent runways, holes, nests and burrows. If the area is one where people or animals are likely to go, put a cover over the trap so that it will be available for nothing but rodents. Boards or boxes can be placed beside and behind the traps to guide rodents into them.

2. For roof rats and mice, place traps on shelves, beams, pipes and other high places.

3. Move the traps around every few days.

4. Check the traps every day.

Remember: **Some traps can hurt people and animals. Use them carefully. Do not let children play with traps. Never use poison in the traps.**

Do not touch dead rats. Rats carry disease. Use a stick or shovel to get them off the trap. Burn dead rats. Wash traps before using them.

Control of rodents with chemicals

Chemical control of rodents works by poisoning, either through a single dose acute poison or a multiple dose chronic poison.

Single dose acute poison: Zinc phosphide (Zn_3P_2) is the most widely used acute poison. Two stages are essential for effective control.

a) Pre-baiting: The sites, baits and containers should be the same as those to be used for the poison at the next stage. The more attractive the bait, the more successful the control. Cooked rice, soaked wheat or maize and flour with syrup are attractive baits. Pre-baiting should be continued for three to four days, freshly prepared bait should be provided each day.

b) Baiting with poison: One part of zinc phosphide is mixed evenly with 19 parts of a bait similar to that used for pre-baiting. The special containers used for pre-baiting should then be furnished with the poison bait and left at dark (when children are already sleeping) in the same positions as the pre-bait containers. The next morning (before the children wake up) the remaining poisoned bait should be removed from the containers and destroyed. The containers should then be replaced, after loading with pre-baiting (non-poisonous) material. If this is eaten it indicates that further control measures are needed, and the whole operation must be repeated. Dead rats and mice should be removed every day and burnt.

Remember **Zinc phosphide is highly toxic to human beings and animals, so handle with great care.**

Multidose chronic poisons:

These are generally blood anticoagulants causing death by internal bleeding. Their main advantage over single dose poisons are as follows:

1. Rodent colonies are not alarmed because death appears to be from natural causes, and they will continue to ingest the poisoned bait. Ultimately giving a better control than single dose poisons;

2. These poisons do not give rise to bait-shyness and no-pre-baiting is necessary; and

3. These poisons are used in very small quantities, and they are slow-acting therefore presenting less risk of accidental ingestion by humans and domestic animals.

Rats are killed in about ten days, although for mice it may take 20 days. Affected rodents seek fresh air and water and therefore generally emerge from the store to die. Carcasses should be disposed of carefully because any anticoagulants remaining there will affect scavenging animals.

The recommended multidose chronic poisons (anticoagulants) are "RACUMIN" and "WARFARIN". About 7 intakes of these anticoagulants are necessary to kill rats and mice. These anticoagulants are available as ready made baits for mixing with baits and/or as powder for dissolving in water.

For the poison bait, the following mixture is recommended:

- 18 parts wheat/maize/rice
- 1 part sugar or salt
- 1 part anticoagulant (Warfarin or racumin)

The baits must always be of a better quality than the stored grain. Crushed grain is preferred. The baits should be kept always fresh. Since rats do not like to eat in the open, baits must be laid out in bait stations. Bait stations must have an entrance and an exit hole. If used outdoors they must be rain proof and on legs to prevent uptake of soil moisture. Bait stations must stay in the same places and positions until the end of the campaign.

The number and places of bait stations depends on the rodents to be controlled.

- For brown rats, bait stations should not exceed a distance of 15 - 20 m to each other and should be placed mostly at the walls or runways.
- For black rats more bait stations are needed and some containers should be fixed on roof beams.
- For mice many small containers, tins or trays must be distributed all over the floor with a distance of about 2 m to each other.

The amount of the poisoned bait for rats is approximately 300 g while for mice it is only about 50 g.

The baiting stations should be checked every day, if there have been complete takes put more bait of poison down. This operation should be continued till the bait is not consumed any more. Remove all dead rats and mice and burn them.

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