PADDY FARMING (652)

NSQF Level 4

(Job Role: Paddy Farmer)

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The course "Paddy Farming" (NSQF compliant level 4), comprising of theory and practical components and is intended to provide you self-confidence and a new avenue to the future. This programme is designated for the youths of rural and semi urban areas like you, who are willing to make their career in the Agriculture sector. After completing this course you will acquire the competencies to cultivate paddy as per the package of practices recommended for a particular agronomic climate zone, type of soil, rainfall pattern and climatic conditions to achieve the yields as per the genetic potential of a given variety and sell the produce as per the competitive market prices without distress sale. After completing this course you will be able to work independently, bear risk, upgrade skills and make decisions pertaining to work area. Sincere efforts have been made to present the matter in a very simple manner for your easy understanding.

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We wish you all the best in your future career.

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How to use the Study Material

Congratulation! You have accepted the challenge to be a self-learner. NIOS is with you at every step and has developed the material in *Paddy Farming* with the help of a team of experts, keeping you in mind. A format supporting independent learning has been followed. If you follow the instructions given, then you will be able to get the best out of this material. The relevant icons used in the material will guide you. These icons have been explained below for your convenience.

Title: will give a clear indication of the contents within. Do read it.

Introduction: This will introduce you to the lesson linking it to the previous one.

Objectives: These are statements that explain what you are expected to learn from the lesson. The objectives will also help you to check what you have learnt after you have gone through the lesson. Do read them.

Notes: Each page carries empty space in the side margins, for you to write important points or make notes.

Intext Questions: Very short answer self check questions are asked after every section, the answers to which are given at the end of the lesson. These will help you to check your progress. Do solve them. Successful completion will allow you to decide whether to proceed further or go back and learn again.

What You Have Learnt: This is the summary of the main points of the lesson. It will help in recapitulation and revision. You are welcome to add your own points to it also.

Terminal Exercise: These are long and short questions that provide an opportunity to practice for a clear understanding of the whole topic.

Answers: These will help you to know how correctly you have answered the questions.

www **Web site:** These websites provide extended learning. Necessary information has been included in the content and you may refer to these for more information.

CONTENTS

Notes

1

INTRODUCTION TO PADDY CULTIVATION

Rice is a staple diet of mankind for more than 5000 years. Today, more than 60 percent of the world population depends on rice. It is grown from the equator to 50^{o}N and from sea level to 2500 m above sea level. About 90 percent of world rice grain is produced and consumed in Asia. In India alone, rice is cultivated on more than 44.6 million ha with an average productivity of 3.0 t/ha. Here, rice is grown under different agro-ecological conditions viz., water logged, deep water, hills, high humidity, high temperature, salinity, alkalinity, and flood prone areas. We are cultivating many types of rice varieties, which play a vital role in national and international trade, as well as major source of foreign exchange.

OBJECTIVES

After reading this lesson you will be able to:

- explain the status of paddy cultivation in India and World;
- describe paddy plant botanically;
- identify growth stages & ecology of paddy;
- explain paddy growing seasons, soil and climatic requirements;
- estimate the nutritional value of rice;
- describe basmati rice;
- explore export potential of paddy.

1.1 ORIGIN AND DISTRIBUTION

Knowing which family a plant belongs to may help you to identify the plant, how it looks like, where the seed pods will be, what the seeds will be like, how to germinate new seeds etc. Paddy belongs to family Poaceae or Gramineae, which is the large and nearly

Notes

ubiquitous family of monocotyledonous flowering plants known as grasses. There are altogether 24 species of genus *Oryza* of which only two viz., *Oryza sativa* and *Oryza glaberrima* are cultivated. *Oryza sativa* is grown in all paddy growing areas, but *Oryza glaberrima* is confined to the West Africa only. South-eastern Asia (India, Myanmar and Thailand) is considered as the centre of origin of paddy.

There are three sub species of cultivated paddy in the world i.e. *Indica* (long grain), *Japonica* (round grain), and *Javanica* (medium grain). *Indica* paddy is grown in warm climate zone of Indo-China, India, Pakistan, Thailand, Brazil and Southern U.S.A., *Japonica* is mostly grown in cold climate zone of Northern China, Korea, Japan and California. However, *Javanica* is grown in Indonesia only.

Have you ever visited a place where you didn't have rice? Certainly not, because paddy is cultivated and available in more than 100 countries of the world. It occupies an area of 156 million hectares in the World with production of 5,98,852 thousand tonnes. China is the largest producer of paddy accounting 31.76 percent of total world production followed by India (22.40 percent). Indonesia (8.52 percent), Bangladesh (5.98 percent), Vietnam (5.44 percent), Thailand (3.91 percent), and Myanmar (3.34 percent) are the other major paddy producing countries. In case of productivity, Egypt ranks first with 9086 kg/ha followed by USA (7037 kg/ha), Japan (6702 kg/ha), and Korea Rep (6592 kg/ha) (Directorate of Rice Development, 2012).

Paddy is a primary food grain crop of India and occupies about 37 percent of the area under foodgrains and contributes more than 40 percent of food grains production in the country. More than 65 percent of country's population depends fully or partially on paddy as it constitutes the main cereal food crop of the human diet. What about your diet? You will be surprised to know that approximately 80% production of rice is consumed in the six states only viz. Andhra Pradesh, Assam, Kerala, Orissa, Tamil Nadu and West Bengal.

The area and production state wise is given below:

S. No.	State	Area (Lakh ha)	Production (Lakh Tonnes)
1.	Andhra Pradesh	40.96	128.95
2.	Assam	25.37	45.16
3.	Bihar	33.24	71.63
4.	Chattisgarh	37.74	60.28
5.	Gujrat	8.36	17.9
6.	Haryana	12.35	37.59
7.	J&K	2.63	5.45
8.	Jharkhand	14.69	31.31
9.	Karnataka	14.16	39.55

Notes

S. No.	State	Area (Lakh ha)	Production (Lakh Tonnes)
10.	Kerala	2.08	5.69
11.	Madhya Pradesh	16.62	22.27
12.	Maharashtra	15.41	28.41
13.	Odisha	44.00	58.07
14.	Punjab	28.18	105.42
15.	Rajasthan	1.34	2.53
16.	Tamil Nadu	19.04	74.59
17.	Uttar Pradesh	59.47	140.22
18.	Uttarakhand	2.8	5.94
19.	West Bengal	54.34	146.06
20.	Others	11.13	24.91

(Directorate of Rice Development, 2012)

1.2 BOTANICAL DESCRIPTION

Till now, somewhere we have used the term rice and somewhere paddy. What is the difference between the two? Actually, there is a minor difference. A complete seed of rice is called paddy and contains one rice kernel. Outer layer of rice shell is called husk. The next layer is called rice bran and the innermost part is called rice kernel. Paddy is a self-pollinated crop. In a self pollinated crop pollen grains are transferred from anthers to stigma of the same flower or another flower of same plant.

You may logically ask why few plants are self pollinated while others are cross or often cross pollinated?

The common cultivated paddy plant is an annual which usually grows to a height of a half meter or two meters but there are certain varieties that grow upto 6-9 metres. Paddy plant can be divided into main two parts namely root system and shoot system.

1.2.1 Root system

Paddy forms the fibrous root system consisting of seminal, nodal and lateral roots. You may observe when a paddy grain germinates in a well drained upland soil, the sheath (coleorhizae) emerges first but if it germinates in submerged low lands, coleoptile emerges ahead of the coleorhizae. The primary embryonic root (radicle) comes out through the coleorhiza shortly after it appears and forms the seminal roots. This is followed by two or

Notes

more secondary roots, all of which develop lateral roots. The embryonic roots later die and are replaced by secondary adventitious roots produced from the underground nodes of the culm. Nodal roots develop on the higher nodes and help the plant to absorb the food material from the surrounding water.

1.2.2. Shoot System

Whatever plant parts you may see above the ground level are collectively called as shoot system. It is mainly composed of culms, leaves and inflorescence (panicle).

(i) **Culm**: The culm or stem is made up of a series of nodes and internodes. The paddy culms are usually hollow except at the nodes. Each node bears a leaf and a bud. Under favorable conditions buds near ground level grow into tillers. The primary tillers give rise to secondary tillers which give rise to tertiary tillers.

(ii) **Leaves:** The leaves of paddy are sessile in nature. They are borne at an angle, on the culm in two ranks along the stem, one at each node. The leaf blade is attached to the node by leaf sheath. The paddy leaf is similar to that of wheat, but is usually distinguished from it by the length of the ligule. In paddy, ligule is very prominent, usually more than one centimetre. The leaf number is more on a primary tiller than on the secondary and tertiary tillers.

(iii) **Panicle:** Paddy inflorescence known as panicle is a group of spikelet borne on the uppermost node of the culm. The primary panicle branch is divided into secondary and sometimes tertiary branches. These bear the spikelet.

(iv) **Spikelet:** The individual spikelet consists of two outer glumes. All the parts found above the outer glumes are collectively called floret. It consists of a hard covering the two sections of which are known as lemma and palea (the glumes) and the complete flower is between them. The lemma and palea together are known as the "hull". The paddy flower contains six functioning stamens (male organ) and a pistil (female organ). At the base of the flower are two transparent structures known as 'lodicules'. Paddy is a self pollinated crop. When paddy flower becomes ready to bloom, the lodicules become turgid and push the lemma and palea apart, thus allowing the stamens to emerge outside the open floret. Rupturing of the anthers then leads to the shedding of pollen grains. After the pollen grains are shed on stigma the lemma and palea closes.

1.2.3 Grain (Caryopsis)

Paddy grain develops after completion of pollination and fertilization. Grain is tightly enclosed by the lemma and palea. The dehulled paddy grain is known as brown paddy as brownish pericarp covers it. Pericarp is the outermost layer which envelopes the caryopsis and is removed when paddy is milled and polished. Embryo lies at the ventral side of the spikelet next to the lemma. Adjacent to the embryo is a dot like structure called as hilum. The embryo contains plumule and radicle. The plumule is enclosed by a sheath known as coleoptile and the radicle by coleorhizae.

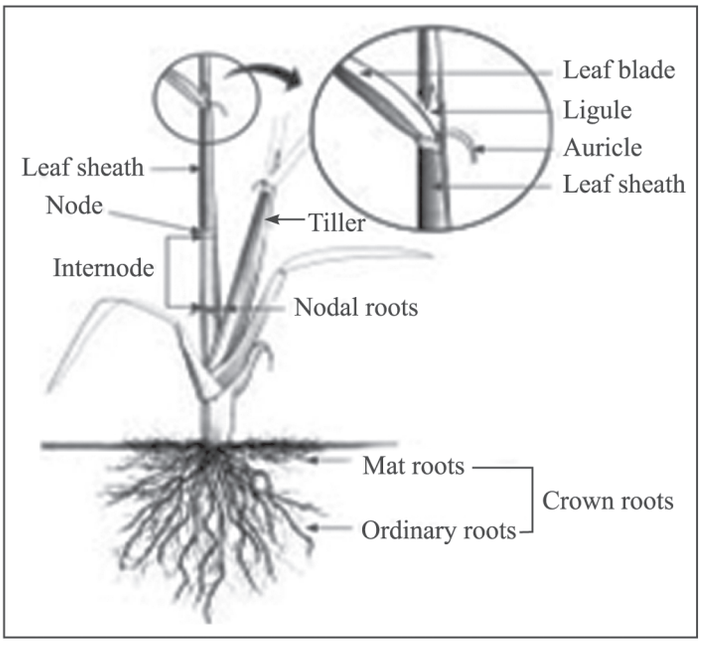

Fig. 1.1: Root and shoot system of rice plant

1.3 GROWTH STAGES OF PADDY

As in human beings we have the growth stages comprising of Infancy, Childhood, Adolescence and Adulthood, paddy plant also undergoes three stages of development:

1. Vegetative
2. Reproductive
3. Grain filling or ripening

1.3.1 Vegetative Stage

The vegetative stage includes germination, pre-tillering and tillering stages. At this stage rice development determines the number of tillers per unit area. Duration of vegetative phase differs with the variety and differences in growth duration. The detail of each growth stage is given here under:

(A) Seed germination

- Development of the embryo into shoot and root is called germination.
- It begins when the seed absorbs water and radicle begins to elongate.
- Inside the germinating seed, starch, protein and fats are digested and translocated to embryo.

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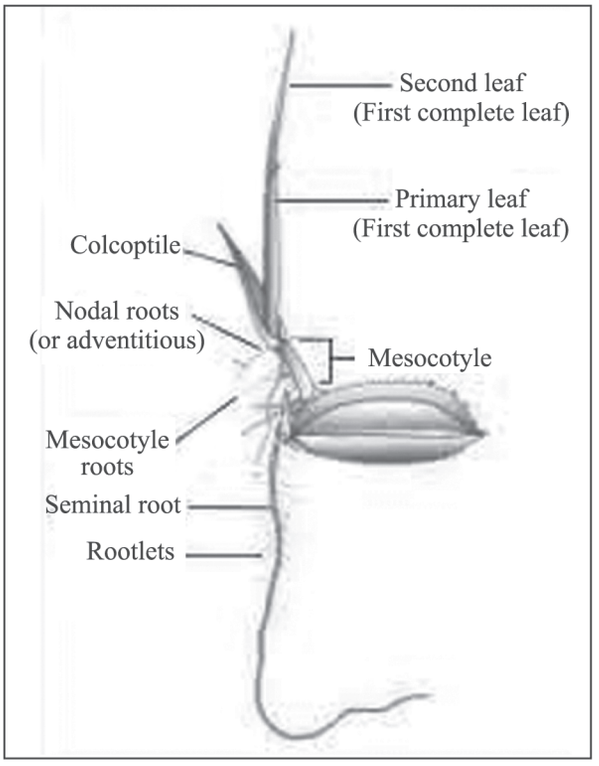

Fig. 1.2: Germinated rice seed

(B) Seedling emergence(spiking)

- Spiking occurs once the radicle has emerged through the soil.
- Warm temperature and good growing conditions can lead to seedling emergence in less than a week.

(C) Seedling establishment (Pre-tillering)

- Root growth and development takes place during this stage. The endosperm can supply nutrients to seedling up to 3 leaf stage.
- Pre-tillering lasts from the development of the first leaf to fourth leaf.

(D) Tillering stage

- Tiller formation begins, when rice is at the 5^{th} leaf stage.
- Tillering continues up to 45 days after transplanting.
- Tillering is affected with cultivar, seed rate, time of sowing, depth of transplanting and nutritional availability.

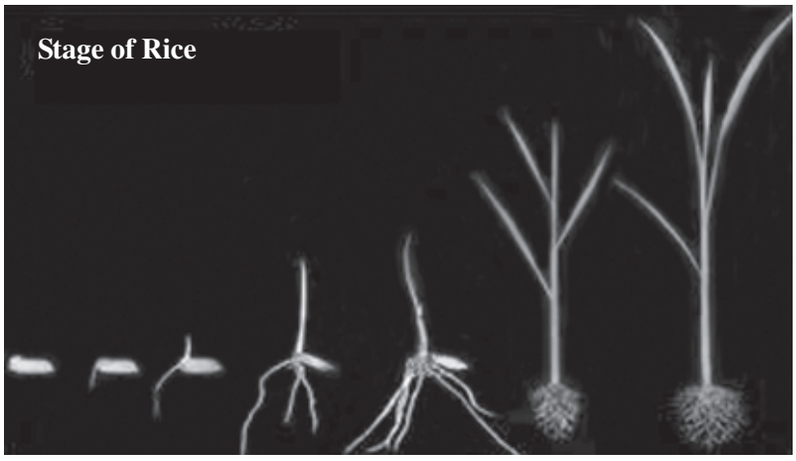

Fig. 1.3: Different vegetative stages of rice plant

1.3.2 Reproductive Stage

The reproductive stage begins from culm elongation and lasts through flower pollination. This stage can be explained in six stages-

(A) Panicle Initiation

- The panicle production begins on the uppermost node of the culm.
- The panicle becomes visible to naked eye about 7 to 10 days after initiation as a white feathery cone.
- Panicle form 3 to 4 weeks before they are noticeable in the field.

(B) Internode elongation

- Once panicle is produced, the top node begins to elongate and move up to the stem, increasing the space between nodes or internode length.
- Other internodes begin to elongate soon afterwards.

(C) Panicle differentiation

- This is a critical time in the reproductive stage because the panicle is sensitive to environmental factors that can affect the formation of a number of grains per panicle.
- This stage occurs when there is approximately ½ to ¾ inch internode elongation on the first panicle.

(D) Booting

- Booting is the final part of the panicle development stage.
- Booting occurs when the panicle grows up through the leaf sheath.

Notes

- The flag leaf and sheath begin to swell. About 16 days after visual panicle initiation, sheath of the flag leaf swells.
- During late boot, the flag leaf is fully extended.

(E) Heading

- Heading stage begins as the panicle emergence from culm.
- When heading begins, 10 to 20 percent of panicles have emerged from the boot.
- Grain matures about 30 to 40 days after heading.
- The phrase "50 % heading" refers to the stage when 50 % of the panicles have emerged from the culm.

(F) Flowering

- Anthesis (blooming or flowering) follows after heading and refers to series of events between opening and closing of the spikelets.
- Flowering begins as the panicles start to emerge from the culm, emerges, usually 22 to 23 days from internode elongation.
- Flowering begins at the tip of panicle and moves down towards the panicle base.
- Flowering usually occurs from mid morning to just afternoon.
- Rice is usually self pollinated, and pollens are shed just before or at the time flowers open.

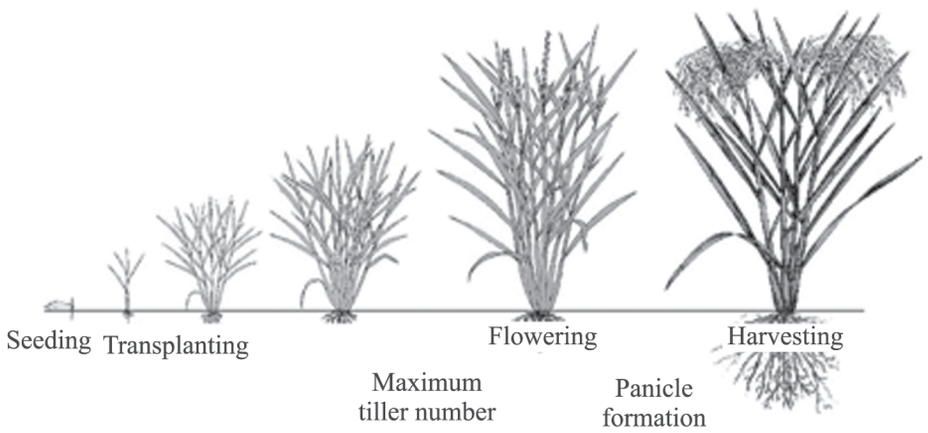

Fig. 1.4: Different growth stages of rice crop

1.3.3 Grain Filling and Ripening

- After flowering, the rice grain reaches its maximum length, width, thickness, and dry weight in 12, 2, 28, and 35 days; respectively.
- Grains mature in the order they flower, from the top of the panicle down to the base.

Notes

- During ripening period, grains go through the milky stage, where they filled with white substance.
- As grains mature, the starch in them gets harder, this stage is called as dough stage.
- Grains are mature when they reach 22 percent moisture.
- At this stage greater portion of the upper leaves are dry and panicle bend down.

1.4 GROWING ECOLOGY

Let us learn the distinct types of ecosystem in which paddy can be cultivated. These are:

Irrigated Paddy Eco System: Irrigated ecosystems are the primary type found in East Asia. Irrigated ecosystems provide 75 per cent of global paddy production. In India, the total area under irrigated paddy is about 22.00 million hectares, which accounts about 49.5 per cent of the total area under paddy crop in the country. Paddy is grown under irrigated conditions in the states of Punjab, Haryana, Uttar Pradesh, Jammu & Kashmir, Andhra Pradesh, Tamil Nadu, Sikkim, Karnataka, Himachal Pradesh and Gujarat. Irrigated paddy is grown in bunded (embanked), paddy fields.

Rainfed Upland Paddy Eco System: Upland zones are found in Asia, Africa, and Latin America. In India, the total area under upland rain fed paddy in the country is about 6.00 million hectares, which accounts 13.5 per cent of the total area under paddy crop in the country. Upland paddy areas lies in eastern zone comprising of Assam, Bihar, Eastern M.P., Orissa, Eastern U.P., West Bengal and North-Eastern Hill region. Upland paddy fields are generally dry, unbunded, and directly seeded. Land utilized in upland paddy production can be low lying, drought-prone, rolling, or steep sloping.

Rainfed Lowland Paddy Eco System: Rainfed low-land paddy is grown in such areas as East India, Bangladesh, Indonesia, Philippines, and Thailand, and it accounts 25 per cent of total paddy area used worldwide. In India, low land paddy area is about 14.4 million hectares, which accounts 32.4 per cent of the total area under paddy crop in the country. Production is variable because of the lack of technology used in paddy production. Rainfed lowland farmers are typically challenged by poor soil quality, drought/flood conditions, and erratic yields.

Flood Prone Paddy Eco System: Flood-prone ecosystems are prevalent in South and Southeast Asia, and are characterized by periods of extreme flooding and drought. Yields are low and variable. Flooding occurs during the wet season from June to November, and paddy varieties are chosen for their level of tolerance to submersion**.**

1.5 GROWING SEASON IN INDIA

The paddy growing seasons vary in different parts of the country, depending upon temperature, rainfall, soil types, water availability and other climatic conditions. In Eastern and Southern regions of the country, mean temperature is found favourable for paddy cultivation through out the year. Hence, two or three crops of paddy are grown in

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a year in eastern and southern states. In Northern and Western parts of the country, where rainfall is high and winter temperature is fairly low, only one crop of paddy is grown during the month from May to November.

INTEXT QUESTIONS 1.1

1. Centre of origin of cultivated paddy is .....
2. The species of genus *Oryza* are ..... but only ..... are under cultivation.
3. *Oryza glaberrima* is cultivated only in .....
4. The inflorescence of paddy is known as .....
5. ..... paddy crops can be taken in Eastern and Southern Indian conditions, however, only ..... crop is grown in Northern & Western India.

1.6 CLIMATE AND SOIL REQUIREMENTS

Paddy crop needs a hot and humid climate. It is best suited to regions which have high humidity, prolonged sunshine and an assured supply of water.

The atmospheric temperature has considerable effect on growth and development of paddy plant. It needs relatively high temperature for optimum growth and development and varies for different growth stages. The critical mean temperature for flowering and fertilization ranges from 16 to 20°C. A temperature range of 25 to 30° C for vegetative growth and 20 to 25°C for grain filling and ripening is best suited. High temperature especially during night leads to loss of reserved food through greater respiration. For higher grain yield a day temperature of 25 to 32°C and night temperature of 15 to 20°C is preferable. Temperature beyond 35°C affects pollen shedding and grain filling. A higher mean temperature ranging between 25 to 32°C per day would reduce the growth duration and accelerate flowering. However, a mean temperature of less than 15°C would slow vegetative growth and plants fail to flowers. Maximum temperature that the crop can tolerate is 40-42° C.

The soil requirements for paddy cultivation differ with climatic regime. Paddy can be grown in soils with texture ranges from sandy to clay, pH from 3 to10, organic matter content from 1 to 50% and salt content from 0 to 1 %.

1.7 NUTRITIONAL VALUE

Rice is main ingredient of our daily meal because of its high energy calorie food. The major part of rice consists of carbohydrate in the form of starch, which is about 72-75 percent of the total grain composition. The protein content of rice is around 7 percent. The protein of rice contains glutelin, which is also known as oryzenin.

The variability of composition and characteristics of rice is really broad and depends on variety and environmental conditions under which the crop is grown. The brown rice is rich in some vitamins, especially B_1 or thiamine (0.34 mg/100g), B_2 or riboflavin (0.05 mg/100g), niacin or nicotinic acid (4.7 mg/100g). In contrast, the white rice is poor in vitamins (vitamin B_1: 0.09 mg/100g, vitamin B_2: 0.03 mg/100g, and niacin: 1.4 mg/100g) and minerals as they are found mostly in the outer layers of the grain, which are removed by polishing process, or "bleaching" whereas parboiled rice is rich in these vitamins as a result of their particular process.

Cooking procedures can reduce the richness of vitamins and minerals in rice. Certain amount of minerals and vitamins are lost even during preliminary washing before cooking. Hence washing with a large quantity of water and repeated washing must be avoided. Washing may remove as much as 40% of the thiamine and nicotinic acid. Rice must be washed, if washing is necessary, with minimum amount of water. Rice is strongly recommended in preparing specific diets against stomach and intestinal disease processes as well as feeding the infants and old people due to its good digestible character.

1.8 BASMATI RICE

When it comes to rice options, basmati rice in its whole-grain form may be one of the better choices. Basmati, which means the 'queen of fragrance', is a variety of long grain rice, famous for its fragrance and delicate flavour. It is derived from Hindi word 'Bas" meaning 'aroma' and 'Mati' meaning 'full of' hence the word Basmati means "full of aroma". Basmati rice gives a lovely side to any meal. This rice is different from other rice varieties mainly due to the post cooking elongation of more than twice its original length, the aroma and its sweet taste. No other rice has this combined characteristic.

It cultivated in a small geographical region of the Indian sub-continent primarily in India and Pakistan. The Himalayan foothills are said to produce the best Basmati.

Types, Area & Production of Basmati Rice

Basmati rice can be divided in two groups i.e. traditional and evolved. There are twenty three varieties of Basmati rice available in India up to 2015. India is the largest producer and exporter of basmati rice in the world. We are producing more than 70% of the total world basmati rice production and the rest is produced by Pakistan. The state wise production of Basmati rice during kharif 2013 was as under:

State	Area (thousand ha)	Production (thousand MT)
Haryana	711	2899
Punjab	590	2293
U. P.	319	1270
J&K	37	93
Uttarakhand	18	54
Himachal	1	3
Total	**1676**	**6622**

(Survey of Agrinet solutions for BEDF, 2014)

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1.9 EXPORT POTENTIAL OF PADDY

India is self sufficient in rice production and having surplus quantity available for export. During 2014-15 the share of rice in agricultural export was 47 % of all agricultural export (21.7% of Basmati and 15.5% of Non Basmati rice).

Major Rice Importer Countries of Basmati:

Basmati rice is exporting in more than 135 countries from India. The top 10 countries are as follows:

1. Iran
2. Saudi Arabia
3. United Arab Emirates
4. Iraq
5. Kuwait
6. Yemen Republic
7. United Kingdom
8. United States
9. Jordan
10. Qatar

Rice Export Status from India

Years	Basmati Rice (MT)	Non-Basmati Rice (MT)
2010-11	2370658	100688
2011-12	3178174	3997720
2012-13	3459899	6687991

(Source: GCIS, 2014-15)

INTEXT QUESTIONS 1.2

1. Maximum temperature to which paddy crop can tolerate is ..... °C.
2. Photo periodically, paddy is a ..... plant.
3. The protein of rice contain glutin is also known as .....
4. Brown rice is rich in vitamins ..... and ..... as compared to milled paddy.

WHAT YOU HAVE LEARNT

Let us recapitulate and enlist salient points we have learnt through this lesson:

- The centre of origin of cultivated paddy is South Eastern Asia.
- There are many species of paddy available but *O. Sativa* is being cultivated in most part of the World.
- Paddy is growing in different eco- system and soils in India.
- Basmati is unique paddy having specific characteristics and cultivated in India and Pakistan only in the world.
- India is earning foreign exchange through export of Basmati and non Basmati paddy in more than 135 countries.

TERMINAL EXERCISE

1. How rice differs from paddy?
2. What are components of a paddy seed?
3. Write short notes on paddy for the following:
   - Root system
   - Shoot system
   - Vegetative growth stage
   - Reproductive growth stages
   - Grain filling and Ripening
4. What is the growing ecology for paddy cultivation?
5. What are the critical temperature requirements for paddy cultivation?
6. Explain the nutritional value of rice.
7. Which type of the soil is required for paddy cultivation?
8. What is basmati rice? How is it different form non basmati rice?
9. Explain the export potential of rice.

ANSWERS TO INTEXT QUESTIONS

1.1

1. South Eastern Asia
2. 24, 02
3. West Africa
4. panicle
5. Two or three ; one

1.2

1. 40-42°C
2. short day
3. oryzenin
4. B_1, B_2, B_3, B_6 & Iron

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2

RICE VARIETIES

Our growing population demands ever increasing crop production. Our farmers and scientists both knows the market demand of rice and due to their joint efforts the rice production recorded a steady upward trend during the last five decades with a threefold increase in production from 34.5 million tonnes in 1960-61 to 104.32 million tonnes in 2011-12. Major credit for increased production goes to the wide scale adoption and development of high yielding varieties. The first official variety GEB 24 was released in 1921. Presently total 1084 varieties are released for wide scale cultivation in different states/ ecology/ zones; including twenty three basmati and seventy two hybrids till 2015.

OBJECTIVES

After reading this lesson, you will be able to:

- explain the improved varieties of rice with their significant characteristics;
- identify the features of popular hybrid and basmati varieties;
- select suitable varieties for your area.

2.1 HIGH YIELDING VARIETIES SUITABLE FOR DIFFERENT AREAS

Let us know the various high yielding varieties of rice and the area suitable for their growth. You should select only the recommended varieties for your region, as are well adapted to the climatic conditions, soil and other biotic and abiotic stresses.

Table 2.1: High yielding recommended rice varieties:

Variety	Duration (Days)	Yield (t/ha)	Recommended areas
Krishna Hamsa	125	4.5 – 5.0	Andhra Pradesh, West Bengal, Tripura, Bihar

Rice Varieties

Notes

Variety	Duration (Days)	Yield (t/ha)	Recommended areas
Rasi	115	4.0-4.5	Andhra Pradesh, Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh
Shanti	125	4.5	Andhra Pradesh
Triguna	130	5.5-6.5	Andhra Pradesh, Maharashtra
Suraksha	135	5.5	Tripura, Assam
Jaya	130	4.5	Gujarat, J&K, Meghalaya, Haryana, Delhi, Rajasthan, Maharashtra, Goa
Improved Samba Mahsuri	140	4.6	Andhra Pradesh, Chattisgarh, Jharkhand, Odisha, Gujarat, Maharastra, Bihar
DRR Dhan 40	135-140	5.09	West Bengal, Chattisgarh, Maharashtra, Gujarat
Swarnadhan	145-150	4.0-4.5	Andhra Pradesh, Tamil Nadu, Karnataka, West Bengal, Assam, Bihar, Odisha
Vikas	125	3.5-4.5	Andhra Pradesh, Bihar, Madhya Pradesh, West Bengal, Kerala
Akshayadhan	130	6.0-6.5	Jharkhand, Andhra Pradesh, Tamil Nadu, Karnataka
DRR Dhan 38		5.5-6.0	Gujrat, Andhra Pradesh
MTU 1010	120	2.5-4.0	Andhra Pradesh
Pusa Sugandha 2	125	6.2-6.5	Punjab, Haryana, Uttarakhand, Delhi, Western Uttar Pradesh
Pusa Sugandha 3	125	6.3-6.5	Punjab, Haryana, Uttarakhand, Delhi, Western Uttar Pradesh
Pusa Sugandha 5	125	6.0-6.5	Punjab, Haryana, Uttarakhand, Delhi, Western Uttar Pradesh, J&K
Pusa 1612	125	6.0-6.5	Punjab, Haryana, Uttarakhand, Delhi, Western Uttar Pradesh. J&K
Pusa 44	140	7.0-8.0	Punjab, Uttar Pradesh, Haryana, Karnataka, Kerala
Jaldi Dhan 13 (PNR 591-18)	80-100	3.5-4.0	West Bengal, Jharkhand, Odisha, Tripura
Jyothi (PTB 39)	110-120	6.0	Kerala
Pushyami (MTU 1075)	135	6.5-8.0	Andhra Pradesh, Maharashtra, Gujarat, Karnataka
Samba Mahsuri (BPT 5204)	150	6.5-8.0	Andhra Pradesh

Notes

Variety	Duration (Days)	Yield (t/ha)	Recommended areas
Vijetha (MTU 1001)	135	6.5-9.0	Andhra Pradesh
Sona Mahsuri (BPT 3291)	140	6.5-8.0	Andhra Pradesh
Nellore Mahsuri (NLR 34449)	125	6.5-8.5	Andhra Pradesh
Mahamaya	125-128	4.5-5.5	Madhya Pradesh, Chattisgarh, Odisha, Tripura
Lalat	95	3.8-4.2	Odisha
Sahbhagi Dhan		3.5-4.0	Jharkhand, Odisha
PR 111	138	6.0-7.0	Punjab
ADT 43	115	5.9	Tamil Nadu
PR 121	140	7.6	Punjab
PR 122	147	7.8	Punjab
PR 113	142	7.0	Punjab
PR 114	145	6.8	Punjab
PR 116	144	7.0	Punjab
PR 118	158	7.2	Punjab
Sarjoo 52	130	5.0-7.5	Uttar Pradesh
NDR 359	130	6.0-7.5	Uttar Pradesh, Bihar, Assam, Odisha
NDR 8002	140-145	3.9-4.5	Odisha, West Bengal, Eastern Uttar Pradesh, Chattisgarh, Madhya Pradesh, Andhra Pradesh
Pant Dhan 12	110	5.5-6.0	Uttar Pradesh, Plains of Uttarakhand
Pant Sugandha Dhan 15	115	3.5-4.0	Uttar Pradesh, Plains of Uttarakhand
Pant Dhan 19	110	5.5-6.0	Nothern western and western zone
VL Dhan-207	160-165	2.0-2.5	Uttarakhand
VL Dhan-208	160-165	2.0-2.5	Uttarakhand
VL Dhan-85	118-125	5.0-5.5	Uttarakhand

Notes

2.2 HYBRID VARIETIES

Have you ever heard about hybrids? Let us understand about it. Hybrid is an innovative technology that was introduced to Indian Agriculture in 1970. Hybrids are expected to give 10 to 15 quintals extra yield per hectare compared with high yielding inbred varieties. First hybrid Rice was developed by China in 1976. Chinese scientist Yuan Longping is known as the father of hybrid rice. India started concentrated efforts on hybrid rice development in 1989. China has the largest area under hybrid rice cultivation. In India 72 hybrids have been released till 2015 by different public and private sector for commercial scale cultivation in different locations/ ecology. Let us have a look on the recommended hybrids in Table 2.2.

Table 2.2: Recommended rice hybrids:

Rice Hybrids	Duration (Days)	Yield (t/ha)	Recommended areas
KRH - 1	120-125	6.02	Karnataka
KRH - 2	130-135	7.40	Bihar, Karnataka, T. N., Tripura, Maharashtra, Haryana, Uttarakhand, Odisa, W. B., Pondicherry, Rajasthan
Pant Sankar Dhan - 1	115-120	6.80	Uttar Pradesh
PHB - 71	130-135	7.86	Haryana, U.P., T. N., A.P., Karnataka
CORH - 2	120-125	6.25	Tamil Nadu
ADTRH - 1	115-120	7.10	Tamil Nadu
Sahyadri	125-130	6.64	Maharashtra
PA - 6201	125-130	6.20	A.P., Karnataka, Bihar, Orissa, M.P., U. P., W. B., T. N., Tripura
PA - 6444	135-140	6.11	U. P., Tripura, Odisha, A. P., Karnataka, Maharashtra, Uttarakhand
Pusa RH - 10 (Ganga)	120-125	4.35	Haryana, Delhi, Western U.P. and Uttarakhand
PRH-122R	130	5.64	Bihar, Orissa, Punjab, U.P., Uttarakhand, Nagaland, Haryana
RH - 204	120-126	6.89	A. P., Karnataka, T. N., Haryana, Uttarakhand , Rajasthan
Suruchi - 5401	130-135	5.94	Haryana, A. P., Karnataka, Gujarat, Odisha, Chattisgarh , Maharashtra
Pant Sankar Dhan - 3	125-130	6.12	Uttarakhand

Notes

Rice Hybrids	Duration (Days)	Yield (t/ha)	Recommended areas
Narendra Usar Sankar Dhan - 3	130-135	5.15	Saline & alkaline areas of U.P.
DRRH - 2	112-116	6.0	Haryana, Uttarakhand, W.B. T. N.
Rajlakshmi (CRHR - 5)	130-135	55	Aasam, Orissa
Ajay (CRHR - 7)	130-135	6.0	Irrigated areas of Orissa
Sahyadri - 2	115-120	6.5	Maharashtra
Sahyadri - 3	125-130	7.5	Maharashtra
HKRH-1	139	9.41	Haryana
CORH-3	115	-	Tamil Nadu
JKRH 401	125	6.22	Bihar, Odisha, W.B., U. P.
Sahyadri - 4	115-120	6.80	Haryana, W. B., U.P. , Maharashtra, Punjab
JRH- 8	105-110	7.50	Madhya Pradesh
DRH - 775	97	7.70	Bihar, Chhattisgarh, Jharkhand, M.P., U.P., Uttarakhand, W. B.
HRI -157 (Arize Prima)	130-135	6.50	Chhattisgarh , Gujarat, Bihar, Jharkhand, Odisha, A.P.,T.N. Maharashtra, Karnataka, M. P.,U. P., Tripura
PAC 835 (PAC 80035) (IET - 18178) Hybrid	130	5.60	Odisha, Gujarat
PAC - 837 (IET - 19746)	130	6.30	Gujarat, Chhattisgarh, J&K, A. P., Karnataka
NK - 5251	128	6.65	A. P., Gujarat, Karnataka, Maharashtra, T. N.
DRRH- 3	131	6.5	A. P., Gujarat, M. P., Odisha, U.P.
US - 312	125-130	5.76	A. P., Bihar , Karnataka, T. N., U. P., W. B.
CRHR-32	125	5.43	Bihar, Gujarat
INDAM 200-017	120-125	6.60	Odisha, Chattisgarh, Gujarat Maharashtra, A.P.
27P11	115-120	5.67	Karnataka, Maharashtra
VNR - 2245 (IET - 20716)	90-95	6.83	Chhattisgarh, T. N.

Rice Varieties

Rice Hybrids	Duration (Days)	Yield (t/ha)	Recommended areas
VNR - 2245 (IET 20735) (VNR-202)	100-105	5.75	U. P., Uttarakhand, W. B., Maharashtra, T. N.
Sahyadri -5	110-115	NA	Konkan Region of Maharashtra
CO (R) H-4	130-135	7.34	Tamil Nadu
Hybrid CO - 4	130-145	7.34	Tamil Nadu, Gujarat, Maharashtra, Uttarakhand, U.P., Chhattisgarh, W.B.., Bihar.
27P31 (IET - 21415)	125-130	8 to 9	Jharkhand, Maharashtra, Karnataka, Tamil Nadu, Uttar Pradesh, Bihar, Chhattisgarh, Madhya Pradesh, Odisha
27P61 (IET - 21447)	132	6.70	Chhattisgarh, , Gujarat, A. P., Karnataka, T. N.
25P25 (IET - 21401)	110	6.70	Uttarakhand, Jharkhand, Karnataka
Arize Tej (HRI 169) (IET - 21411)	125	7. 0	Bihar, Chhattisgarh, Gujarat, Andhra Pradesh, Tamil Nadu and Jharkhand
JKRH 3333 (IET - 20759)	135-140	5.98	W. B., Bihar, Chhattisgarh, Gujarat, A. P.
RH- 1531 (Frontline Gold) (IET - 21404)	118-125	NA	Major Hybrid rice growing regions (M. P., U. P., A. P., Karnataka, Maharashtra)
27P63 (IET - 21832)	132-135	6.0-6.5	A.P, Chhttisgarh, Karnataka, U.P.
KPH - 371	95-100	6.8	Chhattisgarh, Jharkhand, Karnataka, Kerala
VNR - 2375 PLUS (IET - 21423) (VNR – 203)	130	6.8	Bihar, Karnataka, Punjab Maharashtra, Uttarakhand,
Arize - 6444 Gold (HRI-174) (IET-22379)	130-135	7.0	Assam, Chhattisgarh, Odisha, Uttar Pradesh, Bihar, Meghalaya, Karnataka and Tamil Nadu

Notes

Notes

INTEXT QUESTIONS 2.1

1 In India hybrid rice technology was introduced in ..... year.

2 ..... known as father of hybrid rice.

3 Total ..... hybrid varieties are released up to 2015 in India.

4. ..... to ..... q/ha higher yield expected in comparison of ..... varieties from hybrids

2.3 BASMATI VARIETIES

There are 23 basmati varieties released in India till 2015. India is the largest producer and exporter of basmati rice in the World. India produces more than 70% of the total world basmati rice production and the rest is produced by Pakistan. The production of basmati rice in India is 8.7 million tonnes from 2.1 million hectares during 2014-15. Here is the list of notified basmati varieties (Table 2.3).

Table 2.3: Agronomic and quality characteristics of notified basmati varieties

Variety Name	Duration (days)	Yield t/ha	Year of Release	Releasing Institute
Basmati 370	145	2.5-3	1930/ 1973/ 1976	Rice farm, Kalashah Kaku (now in Pakistan)
Taraori Basmati	155	2-2.5	1996	Rice Research Station, (CCS-HAU), Kaul
CSR 30	155	2-2.5	2001/ 2012	CSSRI, Karnal
Ranbir Basmati	135	2.5-3	1996	SKUAST Regional Agriculture Station, R.S. Pura, Jammu
Pusa Basmati 1121	135	4-4.5	2005/ 2008	IARI, New Delhi
Pusa Basmati 1	135	4.45	1989	IARI, New Delhi
Pusa Basmati 6 (1401)	150	4-5	2010	IARI, New Delhi
Pusa Basmati 1509	125	5-6	2013	IARI, New Delhi
Basmati 386	160-165	2-2.5	1997	Rice Research Station, Kapurthala, PAU, Punjab
Basmati 217	155-160	2.5	1969	Rice Research Station, Kapurthala, PAU, Punjab
Mahi Sugandha	140	4-4.5	1995	Rice Research Station, RAU, Banswara, Rajasthan

Notes

Variety Name	Duration (days)	Yield t/ha	Year of Release	Releasing Institute
Haryana Basmati 1	140	4	1991	Rice Research Station, (CCS-HAU), Kaul
Punjab Basmati 1	155	4	1984	Punjab Agriculture University, Ludhiana
Kasturi	130	3.5	1989	Directorate of Rice Research, Hyderabad
Type 3	155	2.5-3	1978	Rice Research Station, Nagina
Punjab Basmati 2	150	4.0	2012	Punjab Agriculture University, Ludhiana
Basmati 564	145	3.5-4.5	2015	SKUAST, Jammu
Malviya Basmati Dhan	140	4.0	2013	Banaras Hindu University, Varansi
Improved Pusa Basmati 1	135	4.5	2007	IARI, New Delhi
Vallabh Basmati 21	121	43.0	2013	SVB Patel Agric. Univ., Modipuram
Vallabh Basmati 22	145	36.21	2009	SVB Patel Agric. Univ., Modipuram
Vallabh Basmati 23	140	34.77	2015	SVB Patel Agric. Univ., Modipuram
Vallabh Basmati 24	143	43	2015	SVB Patel Agric. Univ., Modipuram

Production Area of Basmati Rice

Now you are aware that basmati rice is a unique kind of rice and cultivated only in India and Pakistan. The Himalayan foothills are said to produce the best Basmati. Basmati rice is protected under geographical indication (GI) and the production area of basmati are given in table 2.4.

Table 2.4: Production area of basmati:

S. No.	State	Districts
1	Delhi	Entire state
2	Haryana	Entire state
3	Himachal Pradesh	Entire state
4	Uttarakhand	Entire state
5	Punjab	Entire state

S. No.	State	Districts
6	Jammu & Kashmir	Jammu & Kathua
7	Uttar Pradesh	Agra, Aligarh, Badaun, Baghpat, Bareilly, Bijnore, Bulandshahr, Etah, Etawah, Farukkabad, Ferozabad, Gautam Budh Nagar, Ghaziabad, Hathras, J P Nagar, Kannuj, Mainpuri, Mathura, Meerut, Moradabad, Muzaffar-nagar, Oraiya, Pilibhit, Rampur, Shahjahanpur, Saharanpur

INTEXT QUESTIONS 2.2

1. The production of Basmati rice is ..... million tonnes from ..... million hectare area.
2. Total ..... varieties are released up to 2015 under Basmati group.
3. The area of ..... states come under the Basmati G I Area in India.
4. ..... and ..... are the producer of Basmati rice in the world.

WHAT YOU HAVE LEARNT

Let us recapitulate and enlist salient points we have learnt through this lesson:

- The selection of suitable variety is pre-requisite for high rice production.
- Most suitable variety as per particular area/ season should be selected for cultivation.
- For better yield and productivity, hybrid rice varieties should be selected as per recommendations.
- Basmati rice is GI protected and cultivated in GI area only.

TERMINAL EXERCISE

1. Name any five popular rice varieties of your area with their characteristics.
2. Name 10 hybrid varieties recommended for paddy cultivation.
3. Name 5 Basmati varieties with their characteristics.

ANSWERS TO INTEXT QUESTIONS

Notes

2.1

1. 1970
2. Yuan Longping
3. 72
4. 10, 15, inbred

2.2

1. 8.7, 2.1
2. 23
3. 07
4. India, Pakistan

Notes

3

SEED AND NURSERY MANAGEMENT

In the previous lessons you learnt about the status of paddy cultivation, paddy growing seasons, soil and climatic requirements, different paddy varieties, hybrids & basmati varieties suitable for different regions etc. It is very interesting to know that paddy can be cultivated in a wide range of ecosystems from irrigated to shallow lowlands, mid-deep lowlands and deep water to uplands. Do you know, transplanting is the major method of paddy cultivation in India? What is transplanting? It is one of the major operation in paddy cultivation. Transplanting is defined as the transfer of paddy seedlings from nursery to a well prepared land where plant will complete all growth development stages. Timely transplanting of paddy helps good crop establishment as well as enhanced yield.

However, transplanting is becoming increasingly difficult due to shortage and high cost of labour and scarcity of water which ultimately reduces profit. Thus, direct-seeding is gaining popularity among farmers of India as in other Asian countries. Upland rice, which is mostly dry-seeded, is found in parts of Assam, Bihar, Chhattisgarh; Gujarat, Jharkhand, Kerala, Karnataka, Madhya Pradesh, Odisha, Uttar Pradesh and West Bengal. Wet-seeded rice (WSR) is increasing in area in parts of Andhra Pradesh, Punjab and Haryana.

OBJECTIVES

After reading this lesson you will be able to:

- procure seeds from authentic agency;
- prepare seed for nursery sowing;
- prepare nursery;
- develop healthy seedling;
- plan timely transplanting of paddy crop;
- reduce the exposure of transplanted rice crop to rainfall variability.

Notes

3.1 SEED PREPARATION

3.1.1 Procurement of Seed

You should always procure seeds in advance to get the desired variety of good quality. The agencies from where you can get quality seeds are as under:

- National Seed Corporation (NSC) of India
- State Agriculture Universities and their regional centres
- National and Regional Centre's of ICAR
- Central State Seed Farm
- Haryana Seed Development Corporation

3.1.2 Selection of Seed

You should select the healthy, disease free, true to type, viable seeds with good germination percentage. The certified seeds should be purchased from authorized agency and all characters should be taken care of. The seeds intended for sowing should satisfy the following requirements:

- It should belong to the high yielding variety, as per recommendation for the location.
- It should be clean and free from mixtures of other seeds.
- It should be mature, well developed and plump in size.
- It should be free from obvious signs of age or bad storage.
- It should have a high germinating capacity.

Before sowing, treat the seed with fungicides. This will protect the seeds against seed-borne diseases and also boost the seedlings.

3.1.3 Seed Rate

The seed rates for different type of paddy are as follows:

For Transplanted Rice

- Non Scented Varieties/ hybrid rice: 25-30 kg/ha.
- Scented/Basmati varieties: 12-15 kg/ha.
- SRI Technology: 7.5 kg/ha.

For Direct Seeded Rice (DSR)

- 40-50 kg/ha.

3.1.4 Seed Treatment

Soak the seeds in salt solution (500gms in 10 litres water) for about 10 minutes. Select heavier seeds that settle at the bottom after discarding the seeds that floats in the solution.

Notes

Wash the seeds in clean water immediately after removing from the solution. This will separate the light and unfilled seed from healthy seeds.

Inorganic Seed Treatment

To protect the crop from seed-borne diseases, treat the seeds with carbendazim 50SP @ 2g and streptocycline @ 0.5 g per litre of water solution by soaking for 24 hours. This treatment protects the crop against fungal diseases like blast, brown spot, root-rot, bacterial leaf blight etc. After treatment, dry the seeds under shade before sowing.

Organic Seed Treatment

- Treat the seeds with talc-based formulation of *Pseudomonas fluorescens* @10g/kg of seed and soak in one litre of water overnight. Drain the excess water and allow the seeds to sprout for 24hrs.
- Seed treatment with *Azospirillum* @ 600 g/ha and Phosphobacteria @ 600g/ha or *Azophosphirillum* @ 1200g/ha. Seeds are soaked overnight in these bio-inoculants mixed with sufficient water before sowing in the nursery bed.

Note:

- Biocontrol agents are compatible with biofertilizers.
- Biofertilizers and biocontrol agents can be mixed together for seed soaking.
- Fungicides and biocontrol agents are incompatible.

3.1.5 Time of Nursery Sowing

You should always sow the seeds at right time as recommended below:

- Short duration dwarf varieties/ hybrid rice: 2nd fortnight of May- 30th June
- Medium duration dwarf varieties: 2nd fortnight of May
- Scented/Basmati varieties: First fortnight of June.

3.1.6 Soil and its Management

Paddy grows best on loam to clay loam soils that turn into soft mud when puddle and develop cracks on drying. But, it can also be cultivated on alkaline soils and from well drained to poor drained soils.

INTEXT QUESTIONS 3.1

1. The seed rate for basmati varieties is ..... kg / ha.
2. Seeds are treated with ..... to protect against soil borne diseases and boost the seedlings.

Notes

3. The seed of paddy soaked in ..... solution for separating light and unfilled seeds from healthy ones.

4. For fungicide treatment the paddy seeds are soaked for ..... hrs.

3.2 NURSERY MANAGEMENT

3.2.1 Methods of Nursery Raising

You are required to nurse seeds on seedbed before transplanting paddy seedling into lowland puddled soil. The main reason for nursing paddy seed is to give the seedlings a substantial head start on weeds.

Select a fertile, well drained upland field near the source of irrigation water. Normally for transplanting in one hectare; about 500 m2 area is sufficient for nursery raising. Paddy seed required soaking in water and pre-germinated to raise seedling quickly in the field or seedbed.

Nursery for paddy may be prepared by following method:

- Wet Bed Method
- Dry Bed Method
- Dapog Method
- Nursery for System of Rice Intensification

Each type has advantages and disadvantages, and you will probably end up using different nursing methods depending on the situation. Success in raising healthy paddy seedlings depends mainly on constant supervision of the seedbeds and proper management.

Wet Bed Method

This is widely used in areas where water is abundant. The seed bed is usually prepared 25 to 35 days before trans-planting. Steps involved in raising wet bed seedlings are as follows

- Land where both irrigation and drainage can be controlled should be selected for seed bed. The land should be fertile and free of excess salts or other soil problems.
- The seed bed area is ploughed twice and then puddle by giving two or three more ploughings. After 10 days, the field is again ploughed twice and levelled.
- When the field is brought to fine soft puddle condition, raised beds (4 - 5 cm high) of 1.2 m wide and of convenient length with 45 cm channel all around are constructed. Raised beds are not necessary in areas where water- logging is not a problem. Excess water is drained off to maintain a water level just sufficient to cover the soil. The surface of the seed bed is so levelled that there is gradual inclination toward both sides to facilitate drainage of water during the first few days.

Notes

- For each 100 m^2 area of nursery bed, provide 1 kg N_2, 0.4 kg P_2O_5 and 0.5 kg K_2O. Double the P_2O_5 application in locations where cool temperatures retard the growth of seedlings. The fertilizers are mixed with soil before sowing.
- Sow (broadcast) pre-germinated seeds (soak the seeds for 24 hours, incubate in warm moist conditions for 36-48 hours until germination) on a drained bed at the rate of 50 - 70 g (unsoaked weight basis) per square meter depending upon the size of the seed. If seeds are sown too closely seedlings will be weak. It will be also more difficult to pull seedlings and there will be more chances of injury to the long roots of adjacent seedlings.
- Keep the beds moist for the first few days. Do not flood the beds. When the seedlings are about 2 cm high, keep the beds submerged in a shallow layer of water.
- Top dress the seed beds with 0.3 kg to 0.6 kg N_2 per 100 square meter area, 6 days before transplanting.
- Appropriate control measures should be taken for pests and diseases in the nursery if they occur.
- The four leaf stage (20-25 days after sowing) is generally regarded a optimal seedling for transplanting.

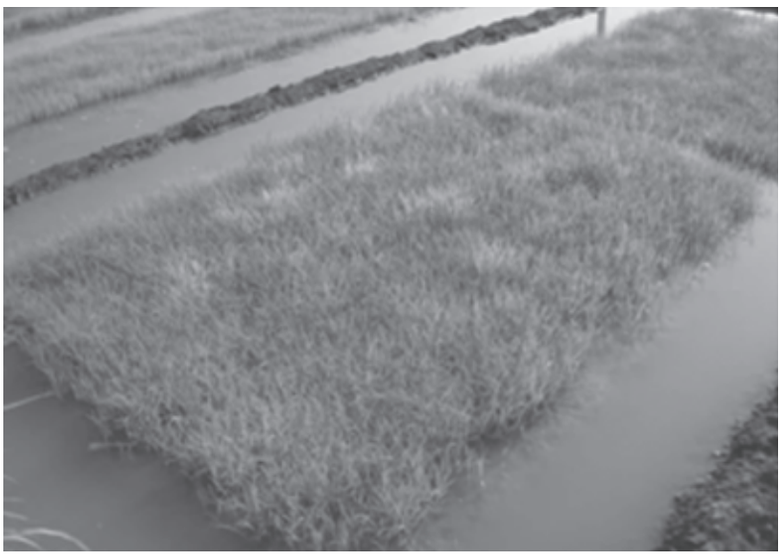


Fig. 3.1: Nursery prepared with wet bed method

Advantages

- It can grow in any type of soil.
- Less seed is required per unit area.
- Seedlings grow rapidly, uniform and healthy in nature.
- Seedlings easy to uproot.
- It can withstand slight salinity.

Notes

Disadvantages

- Copious water is essential.
- Labour intensive.
- Seeds are easily carried by rainwater if a heavy rain occurs shortly after sowing.
- It is difficult to arrest seedling growth.
- Seedlings cannot be kept longer in the nursery as they tend to tiller and produce nodes under the favourable conditions.
- It requires more space and this entails in loss of space where crops are standing.
- Seedlings cannot withstand drought.

Dry Bed Method

If your region is rainfed (depends upon rain water for crop irrigation) or there is water scarcity in your area, you have to make nursery by dry bed method. For this, select a level or gently sloping area near a convenient water source. Plough and harrow the soil twice to obtain a fine tilth. At least 10-15 cm of topsoil must be opened up and well pulverized. Addition of well decomposed organic matter/FYM/partially burned rice straw or rice husks will help to keep the soil aerated. Peg out the beds in the same manner as wet beds. Broadcast the pre-germinated seed evenly where there is sufficient moisture in soil or in the anticipation of rainfall. Be careful to cover the seeds completely with a thin layer of soil. If heavy rains or birds threaten, cover the beds with fronds or leaves.

The beds should be watered thoroughly, immediately after seed sowing and twice every day thereafter. Soak the bed well (to near saturation). If irrigation water is available, water can be sent along the channels and splashed onto the beds, otherwise water must be applied manually. If the beds dry out for even one day, the growth of the seedling may be seriously impaired. Do not construct dry bed nurseries unless sufficient water is available.

Fig. 3.2: Bed for dry bed type nursery

Notes

Dry bed seedlings will not grow as fast as wet bed seedlings. Seedlings on the dry bed will be ready for transplanting from 25 days onwards. Water the bed to saturation before uprooting to make sure the soil is moist and loose.

Advantages

- Seedlings develop excellent root.
- Hardy seedlings develop that can tolerate adverse condition.
- Seedlings are easy to uproot.
- Beds can be made near to your house.

Dapog Method (Mat type)

If you are planning to grow short duration paddy varieties, Dapog or Mat type method is most appropriate. This method of raising seedling was originated in the Philippines and is now, fairly common in South and Southeast Asia. While in India, it is commercially adapted in Andhra Pradesh. Mat type nursery is raised for machine transplanting. The dapog nursery is constructed to raise seedlings without any soil. Rice seeds contain sufficient food in the endosperm to permit the young seedling to grow for up to 14 days without receiving any outside nutrients except air, water, and sunlight. Consequently, it is possible to nurse seedlings without actually sowing them in soil. A sheet of polythene is place on the levelled nursery bed and a compost layer to a height of 1.5 - 2.0 cm is placed on it. Sprouted seeds are then sown to a density of 1 kg/m^2. Gently sprinkle water over the seeds, taking care not to dislodge them. From about the third day, keep the bed continuously flooded with a thin layer of water. Regardless of duration of the variety, dapog-raised seedlings will be ready for transplanting after 12-14 days. On the day of transplanting, simply roll up the entire seedling mass (the roots will have matted together to form a soft of rug), throw it over your shoulder, and head for the field.

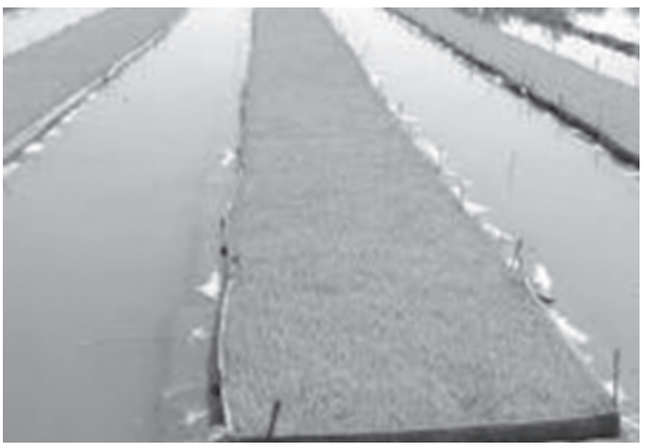


Fig. 3.3: Mat type rice seedling

Notes

Advantages

- Fastest method of raising seedlings, it takes half time as compared to other types.
- Small nursing area is required.
- Beds may be made near to your house.
- Dapog seedlings recover fast from transplanting because they are not uprooted.

Nursery for System of Rice Intensification (SRI)

Let us learn nursery preparation for system of rice intensification.

- First soak the paddy seeds in water for 24 hours and discard the irregular or floated seed.
- Prepare the seedbed as closely as possible to the field, so as to minimize transport time between seedling removal from the seedbed and their transplanting in the field.
- Prepare a mixture of compost (20% FYM/vermicompost/poultry manure) + soil (70%) + rice husk/ sand (10%). Prior to seeding, lay down the prepared mixture on the plastic sheet or used polythene/gunny bags spread on the shallow raised bed (to prevent root going deep into soil).
- Broadcast the pre-germinated seeds onto the bed at a rate of about 200 grams for every 3 square meters, and then cover the seeds with a fine layer of soil.
- Water the seedbed every day in the late afternoon, or as often as needed to maintain a moderate level of soil moisture. The soil should not be saturated or kept continuously wet. If there has been rain during the day, no need of watering.
- Transplanting should be done when the seedlings have just two leaves stage. This usually occurs between 8 and 12 days.
- All seeds should not be sown at the same time. Rather, appropriate batches of seed should be sown on successive days, so that the plants when they are put into the field can be a uniform age, all between 8 and 12 days.

Fig. 3.4: Seedling ready for transplanting through SRI technology

Notes

3.3 WEED MANAGEMENT

You need to manage weeds in nursery judiciously. Following practices may be done:

- Prepare nursery area two weeks before seeding.
- When using soil mix for nursery beds, make sure the soil is clean and free from weed seeds.
- Apply any one of the pre-emergence herbicides viz., Pretilachlor 30 EC + safener @ 1.5 *l*/ha, within 3 days after sowing or Butachlor 50 EC @ 3.0 *l*/ha (or) Pendimethalin 30 EC @ 3.0 l/ha (or) Anilophos 30 EC @ 1.25 *l*/ha at 6 days after sowing by mixing in 60 kg dry sand. Keep a thin film of water and allow it to disappear. Avoid drainage of water. This will control germinating weeds.
- If weeds appears later in nursery bed apply post emergence herbicide Bispyribac Sodium 10 % SL @100 ml /ha at 15 days after sowing.

3.4 WATER MANAGEMENT

You should be conscious and proper care should be done to avoid stagnation of water in any part of the seedbed. Allow enough water to saturate the soil from 3rd to 5th day. From 5th day onwards, increase the water depth to 1.5cm depending on the height of the seedlings. Thereafter maintain 2.5 cm depth of water.

3.5 FERTILIZER MANAGEMENT

Let us understand the fertilizer management in different methods of nursery raising.

3.5.1 Dry and Wet Bed Nursery

1. Apply well-rotten Farm Yard Manure or compost @ 2 kg/m_2 nursery bed area before bed preparation.
2. In less fertile soils, a basal application of 50g DAP/m_2 nursery bed is used.
3. DAP application at 15 days after sowing is recommended for good growth and easy uprooting of seedlings.

3.5.2 Dapog Nursery

1. FYM must be applied @ 2.5 kg/m_2 area during bed preparation.
2. 100 m_2 nursery should be applied 0.5 to 1 kg of nitrogen, 0.5 kg phosphorous and 0.5 kg of potash fertilizers.

3.6 UPROOTING OF SEEDLING

It is necessary to identify the optimum age of seedling for transplanting. The optimum age of nursery for transplanting is 20-25 days after sowing while in case of SRI technology

Notes

it should be 8-12 days old. The seedbed should be watered a day prior to the uprooting of the seedlings (submerge the soil, not the seedling) to minimize damage to the seedlings and easy uprooting.

Uproot few seedlings at a time by holding them from the base as low as possible and pulling sideways. Always handle seedlings with extreme care. Seedlings that are handled gently during uprooting and transporting recover much more quickly when transplanted. To remove mud, wash the seedlings gently in water.

3.7 SEEDLING TREATMENT

After uprooting and removing mud, treat the seedlings with carbendazim 75% W.P @ 2g and streptocycline @ 0.5 g per litre of water solution. For this dip the roots of seedling in solution for 20 minutes. It will help in protecting the crop from various fungal and bacterial diseases.

INTEXT QUESTIONS 3.2

1. The Herbicide use as post-emergence

   (a) Pendimethaline (b) Bispyribac Sodium

   (c) Pretilachlor (d) Anilophos

2. The area required for raising nursery for 1 ha is

   (a) 2000 m^2 (b) 750 m^2

   (c) 500 m^2 (d) 1500 m^2

3. The age of seedling in SRI is

   (a) 8-12 days (b) 15-20 days

   (c) 20-25 days (d) 25-30 days

4. Pretilachlor is herbicide applied in paddy nursery as

   (a) Post emergence (b) Pre-emergence

   (d) Pre plant incorporation

WHAT YOU HAVE LEARNT

Let us recapitulate and enlist salient points we have learnt through this lesson:

- Timely transplanting of rice helps good crop establishment. It is advised to start preparing nursery in early June and transplant the seedlings in early July.

- Seed should be certified, healthy, disease free, true to type, viable with good germination percentage.
- To protect the crop from seed-borne diseases treat the seed with carbendazim 50SP @ 2g and streptocycline @ 0.5 g per litre of water solution by soaking for 24 hours.
- Three types of nurseries are commonly used: Wet Bed Method, Dry Bed Method and Dapog Method.
- Transplanting of 8-12 days old seedling is done for System of Rice Intensification (SRI).
- Pre-emergence & post emergence herbicides may control the paddy weeds completely.
- As per nursery prepared recommended doses of fertilizers should be applied.

TERMINAL EXERCISE

1. What are the prerequisite to select seed for sowing?
2. What is the recommended seed rate for paddy?
3. Explain the methods of seed treatment for paddy.
4. Differentiate the Wet Type and Dapog type method of nursery raising.
5. What are the advantages and disadvantages of wet bed nursery?
6. Explain weed management in paddy nursery.
7. Explain nursery management for SRI.

ANSWERS TO INTEXT QUESTIONS

3.1

1. 12-15 2. fungicides 3. salt 4. 24

3.2

1. (b) (Bispyribac sedium)
2. (c) (500 m^2)
3. (a) (8-12 days)
4. (b) (Pre-emergence)

4

LAND PREPARATION AND TRANSPLANTING

After developing healthy seedlings in nursery it is necessary to transfer them in well prepared land, where the crop will grow and complete its life cycle. Can you guess why the land preparation plays an important role in establishment of the seedlings? Let us understand it. A well prepared, pulverised land provides good condition for proper root growth and development. It facilitates good crop establishment, weed control and utilization of available nutrients. It provides a soft soil mass for transplanting and a suitable soil surface for direct seeding. As paddy is grown in diverse land and ecosystem, land preparation practices varies accordingly.

OBJECTIVES

After reading this lesson, you will be able to:

- explain the basics of land preparation;
- prepare land for transplanting;
- perform transplanting;
- discuss paddy transplanting methods.

4.1 LAND PREPARATION

The land preparation is dependent on method of planting and moisture availability. The land preparation for paddy cultivation covers a wide range of operations as mentioned below:

- Ploughing
- Harrowing

Notes

- Puddling and
- Levelling

You should begin land preparation 3-4 weeks prior to transplanting.

Ploughing

Ploughing is the primary tillage operation. It involves cutting, breaking and inverting the soil partially or completely suitable for sowing seeds.

Ploughing is done to:

- Obtain a deep seed bed of good texture.
- Increase the water holding capacity of the soil.
- Improve soil aeration.
- Destroy weeds, insects and pests.
- Add fertility to the soil by covering soil surface with vegetation.

Harrowing

Harrowing is a secondary tillage operation which is done to a shallow depth for smoothening and pulverizing the soil. It also cut the weeds and mixes the organic and inorganic fertilizers with the soil.

Harrowing is done to:

- Pulverize the soil of the seedbeds in the field.
- Destroy grasses and seeds in the field.
- Cut crop residues and mix them with top soil of the field.
- Break the big clods and to make the field surface uniform and levelled.
- Harrowing is carried out when moisture content of the clods are reduced.

Puddling

Puddling is the churning of soil with water. Churning of soil is done in paddy fields with standing water of 5-10 cm depth after initial ploughing with country plough or mould board plough. It breaks up the clods and churns the soil.

Puddling is done to:

- Reduce the percolation loss.
- Incorporate of green manure is possible.
- Make the soil soft for easy transplanting.

Notes

- Control the weeds better.
- Increase the nutrient availability.
- Establish reduced soil condition, which improves soil fertility and fertilizer management.

Shortcomings in Puddling:

- High water requirement for puddling.
- Create hindrance to regeneration of soil structure.
- Impediment to root development due to formation of hard pan.
- High power requirement.

Levelling

Land levelling is expected to bring permanent improvement in the value of land. Levelling work is carried out to modify the existing contours of land for efficient agricultural production system.

Purposes of Levelling:

- Efficient use of irrigation water and increased conservation of rain water.
- Improve surface drainage and minimize soil erosion.
- Provision of an adequate field size and even topography for efficient mechanisation.
- Efficient weed management.
- Improves better crop stand and crop establishment.

Benefits of Land Preparation

The common benefits of land preparation are as follows:

- Controls weed.
- Provides a fine tilth to soil for water intake and nutrient adsorption.
- Uniform incorporation of fertilizers.
- Improvement of soil porosity and aeration.

Tillage operations vary according to the following factors

- Water availability
- Soil texture
- Land topography
- Resources available to the farmers

Notes

4.2 FIELD PREPARATION UNDER DIFFERENT METHOD OF CULTIVATION

The most important factor for the growth and yield of paddy are timeliness and quality of land prepared. Land preparation practices of paddy as wetland or dryland depends on the establishment technique to be followed (viz. transplanting, direct seeding or drilled seeding), moisture supply and resources available with the farmers.

4.2.1 Field Preparation for Lowland (Wet land)

The land preparation techniques in low lands are more or less similar with different plant stand establishment methods either transplanted or direct seeded. Wetland tillage consists of following steps for field preparation which uses one third of total water supply in growing a paddy crop:

(i) Ploughing

Open up the soil during summer season through mould board plough to expose weed seeds, egg of insects to sunlight and reduce the incidence of insects. It helps to store the soil moisture during cropping period. After ploughing practice, tillage should be done repeatedly through harrow and cultivator followed by planking.

Fig. 4.1: Summer ploughing and land preparation with different implements

Notes

(ii) Land Levelling

Land levelling is an important part of land preparation. A levelled field allows paddy planter or seed drill to place seed more precisely. Land levelling enables more uniform irrigation, crop establishment and improved fertilizer use efficiency. Levelling also helps to reduce irrigation water input. Land levelling is best achieved using laser land leveller.

Fig. 4.2: Land levelling with different implements

(iii) Land Soaking

In this process, field is filled up with water 1 or 2 days before puddling and allow water to soak in until soil is saturated. Keep the surface of the field covered with water to a depth of 5-10 cm for puddling. Stagnation of water in patches during germination and early establishment of crop leads to uneven crop stand in direct seeded rice.

(iv) Puddling

Puddling is very important operation for preparation of seed bed for transplanting the paddy seedling. It helps to check the weed growth, conserves water, improves water holding capacity, nutrients availability and ultimately improves the crop yield. Puddling is associated with churning of the soil to change its physical properties like bulk density, percolation rate, porosity and penetration. It is a simple soil operation that eases transplanting and reduces water losses through percolation. Puddling is done with the help of plough/tractor mounted cage wheel/cultivator in standing water of 50-100mm depth in the field that has already been ploughed once during dry conditions by which the big clods of soil are broken. Puddling of soil results in destruction of 91-100 % of macro pore volume and restricts porosity. Puddling should be done twice in cross direction and fertilizer should be applied after first puddling so that nutrient can be placed in reduced zone. An important difference between a dry field and puddled lowland field is the presence of the reduced soil layer in the puddled soil system.

Fig. 4.3: Puddling through different implements

4.2.2 Upland (Dry Land) Preparation

Many system of rice cultivation are based on dry land preparation e.g. dry seeding, drill seeded rice, broadcast seeded rice and rainfed upland. The land preparation is more or less similar in all dry land (upland) paddy cultivation.

Following are the reasons for using dryland preparations:

- Initial crop growth is obtained from early monsoon rainfall which would be used for land soaking.
- Less labour requirement due to direct seeding.
- Insect and disease build up on alternate host are reduced.

Land preparation on upland or dryland includes following steps:

(i) Summer Ploughing

Summer ploughing has proved beneficial in increasing water infiltration rate and thus in a higher production of upland rice due to increased moisture availability and less weed infestation. The field should be ploughed with soil turning plough after harvesting of rabi crop in the month of April-May.

(ii) Secondary Tillage

The main objective is to prepare a fine seed bed. Field should be prepared by cross harrowing followed by cultivator along with planking for getting fine tilth. Apply gypsum @ 1 t/ha basally during field preparation wherever soil crusting and soil hardening problem exist. After harrowing and cultivator, perfect land levelling must be done through laser land leveller and then bund should be made around the field to check loss of rain water by runoff.

(i) **In *vattar* field (unpuddle) with delayed first irrigation:** Prepare the *vattar* field with 2-3 ploughings followed by planking. Just after that, sowing should be done with drill at a depth of 3-5 cm. It should be immediately followed by planking to avoid moisture loss and firm seed to soil contact. The field preparation and sowing operations should be done in the evening hours to avoid moisture loss.

Notes

(ii) In dry field (unpuddle) immediately followed by irrigation: Prepare the field with 2-3 ploughings followed by planking. Sowing should be done with drill at a depth of 2-3 cm without any planking after sowing. Irrigate the field just after sowing.

INTEXT QUESTIONS 4.1

1. ..... helps to store the soil moisture during cropping period.
2. For puddling, field is filled up by water to ..... cm depth in lowland field preparation.
3. Land leveling is done through ..... more precisely.
4. In low land preparation, water and power requirement is more than upland field preparation due to ..... operation.

4.3 TRANSPLANTING

Transplanting is an important method of crop establishment in low land paddy. Paddy seedlings are transplanted in puddled field, therefore proper puddling and levelling are needed for easy transplanting. Paddy planting is normally done manually in line or randomly. Now, mechanized transplanting is also preferred. In wet or lowland cultivation of rice, transplanting is advantageous for the following reasons:

- It enables to have optimum plant population at desired spacing in the field.
- Since the nursery occupy only a small area of the field, the control of insect, disease, irrigation and manuring of young crop is easier and cheaper than direct sown.
- It enables a thorough cultivation and puddling operation to the field which keep down the weeds.

4.3.1 Time of Transplanting

It is important to transplant the seedlings timely. The time of transplanting varies with the season and area of planting. The ideal date for sowing of seeds in Northern India is between the end of June and first week of July. The nomenclature and planting/sowing time along with harvesting are as follows:

Crop	Season	Transplanting time	Harvesting time
Early	Aus-Autumn	May-June	September-October
Rainy Season	Aman- Winter	June-July	November-December
Summer Season	Boro-Spring	November-December	March-April

Notes

4.3.2 Spacing

You have to take care for proper spacing between the seedlings in the field. It is estimated that a correct spacing can increase the yield by 25-40% over improper spacing. It also saves money on inputs, labor, and materials. The ideal spacing for transplanting of seedlings should be done at 20 × 20 cm^2. Closer spacing (15 × 15 cm^2 or 10 × 10 cm^2) may be used depending upon the availability of planters. In general spacing should be 20 × 15 cm^2 apart during *Kharif* and 15 x 15 cm^2 in *Rabi* season.

4.3.3 Number, Age and Depth of Transplanting

The most ideal seedling for transplanting is 4 leaves stage. They may have 3 leaves but the seedling should not have more than 5 leaves. Normally, this stage of seedlings may come between 20 to 30 day old nurseries. In general, flat recommendation is to use seedlings of 21-25 days old. Usually 2-3 seedling should be planted per hill at 2-3 cm depth (shallow). In case of more than 25 days old seedlings are to be planted than number of seedlings should be 3-4/hill.

4.3.4 Method of Transplanting

Have you ever done or seen paddy transplanting? Let us learn the different methods for paddy transplanting:

A. Manual Transplanting

Majority of paddy fields in Asia are manually transplanted. Transplanting of seedling is done by the labours. Depending on soil type, one hectare of transplanting requires 40 to 50 man days to establish. You may perform manual transplanting in two methods:

(i) **Line Planting:** This method follows uniform spacing or pattern. Paddy seedlings should be planted in line to maintain plant population and easy management. Straight rows facilitate management practices such as hand or rotary weeding and application of fertilizers, herbicides, or insecticides. Optimal plant spacing may also be achieved through this method. Ropes are stretched along the field and planting is carried out keeping the rope as base line. The spacing between the rows varies from 15 to 30 cm as per the variety and age of seedlings. In general, intra row spacing of 15 to 20 cm is adopted. A rogue spacing of about 30 cm is left after every 10-15 rows to facilitate after cultivation practices.

(ii) **Random or bulk Planting:** In random method, seedlings are transplanted without a definite distance or space between plants and rows. In random method of planting, entire field is divided into numbers of strips having a width of 1.5 to 2.0 m with convenient length. A rogue spacing of 30 cm is allowed between strips. Seedlings are then spread in each strip and planting is carried out. In this type of planting, optimum plant population and spacing between the hills cannot be maintained but it depends on the skill of labourers.

Notes

B. Mechanical transplanting

As we all want to complete our work fast, mechanical transplanting is always a preferable option. Mechanical transplanting requires considerably less time and labour than manual transplanting. One hectare of land requires 2-3 man days to establish. The paddy field must be well prepared for machine transplanting. For mechanical transplanting, seedling in special mat nurseries or in seedling tray is required. Ensure that fields are well puddled and levelled.

Nursery raising for mechanical transplanting: Raise seedlings in special mat nurseries or in seedling trays. Use 18-25 kg of quality seed per 100 m^2 of nursery for each hectare. Seedlings will be ready for transplanting in 15-21 days after seeding (DAS). Grow seedlings on a thin layer of soil in 30 cm × 60 cm^2 trays per seedling box. In some instances, seedlings are grown on larger areas and then cut into rectangular strips (mats of seedlings) that fit into the planting trays of the transplanter.

Transplanting with Transplanter: Mechanical transplanters have built-in trays or seedling boxes. Drain fields and allow mud to settle for 1-2 days after the final puddling. The subsurface soil layers need to be hard enough to support the transplanting machine. Load the seedling mats on the machine and transplant the seedlings at the selected machine setting.

Fig. 4.4: Manual and mechanised transplanting

Notes

INTEXT QUESTIONS 4.2

1. The ideal spacing or manual transplanting is ..... cm^2.
2. How many seedlings should be planted on a hill, if seedlings are 30 days old?
3. For mechanised transplanting, ... type nursery is required.
4. ..... man days are required for one hectare land transplanting.

WHAT YOU HAVE LEARNT

Let us recapitulate and enlist salient points we have learnt through this lesson:

- Land preparation practices provide condition for rapid water intake and temporary storage of water on soil surface which helps in preventing water runoff.
- For paddy cultivation, the method and degree of land preparation are related to method of planting and moisture availability.
- The land preparation techniques in low lands are more or less similar with different plant stand establishment methods either transplanted or direct seeded.
- Wetland preparation includes ploughing, levelling, water soaking and puddling.
- Puddling is associated with churning of the soil to change its physical properties like bulk density, percolation rate, porosity and penetration. It is a simple soil operation that eases transplanting and reduces water losses through percolation.
- Transplanting is an important method of crop establishment in low land rice cultivation. Rice seedling are transplanted in puddled field, therefore proper puddling and levelling are needed for easy transplanting.
- Paddy planting is normally done manually in line or randomly and mechanised planting is also popularising.
- In the manual transplanting, the seedlings are transplanted at 2-3 seedlings/hill on the spacing from 15 to 30 cm as per the variety and age of seedlings in line planting or in strip of 1 to 1.5 m in random planting.
- Mechanical transplanting requires considerably less time and labour than manual transplanting. For mechanical transplanting, seedling in special mat nurseries or in seedlings trays is required.

TERMINAL EXERCISE

1. Explain the following:
   - Ploughing
   - Harrowing

Notes

- Puddling
- Puddling
- Transplanting

2. Why land preparation is an important step in crop production?
3. Explain the field preparation for lowland.
4. Explain field preparation under upland condition.
5. Explain the benefits of puddling?
6. Explain the manual methods of transplanting.
7. Give a short note on mechanical transplanting.

ANSWERS TO INTEXT QUESTIONS

4.1

1. Summer ploughing
2. 5-10
3. laser land leveller
4. puddling

4.2

1. 20 × 20
2. 3- 4
3. mat
4. 40-50

Notes

5

IMPROVED SOWING METHODS

In the previous lesson we learnt about land preparation and transplanting of paddy seedlings. Besides raising nursery and then transplanting the crop you may also sow the paddy seed directly in prepared land. Different methods of seed sowing are used for various rice cultures e.g. rainfed lowland, lowland rice culture under irrigated culture, deep water rice culture and upland rice culture. Application of appropriate method of sowing depends upon the availability water and resources to farmers. In India, approximately 70 % of available surface and ground water is used for agriculture. Being a semi-aquatic plant, 60 per cent of total water used for crop production is used for paddy production.

We all are aware that water is limiting natural resource and its availability is decreasing day by day. Hence, there is need of improved cultivation techniques by which higher yield can be obtained under fewer water supplies. Direct seeded rice (DSR) in upland as well as lowland and transplanted rice through System of rice intensification (SRI) in lowland is the advanced paddy sowing methods which utilizes water judiciously and precisely.

OBJECTIVES

After reading this lesson you will be able to:

- explain direct seeding of paddy under various conditions;
- perform broadcasting of paddy seeds;
- sow paddy seeds using seed drill;
- sow paddy seeds by dibbling;
- sow paddy seeds using drum seeder;
- discuss principle and benefits of systems of rice intensification;
- practice the techniques of SRI.

Notes

5.1 METHODS FOR DIRECT SOWING

Even if you missed the nursery sowing and transplanting dates don't worry. You may go for direct sowing. There are many benefits of this method, as direct seeded crops require less labour and tend to mature faster than transplanted crops. Also, the plants are not subjected to stresses such as being pulled from the soil and re-establishing fine rootlets. However, they have more competition from weeds.

Following are the methods of direct paddy sowing:-

(a) Direct seeding methods for dry soil

  (i) Broadcasting

  (ii) Drilling with seed drill

  (iii) Dibling

(b) Direct seeding methods for wet soil

  (i) Broadcasting of sprouted seed on puddled soil

  (ii) Seeding with drum seeder in puddled soil

All the above methods of direct seeding are broadly applied to dry and wet land preparation.

5.1.1 Direct Seeding Techniques for Dry Soil

You may sow the seed on a dry soil surface and then cover with soil either by ploughing or by harrowing, in *rainfed* and *deepwater ecosystems*. For getting good plant stand in direct seeding, proper field preparation, appropriate seed quantity and soil moisture must be assured. Direct seeding onto dry soil can be done by any of the following methods:

Broadcasting

Broadcast seeds freely or in furrow on well prepared field through harrow. After broadcasting, cover the seeds by spike-tooth harrow.

Drilling with Seed Drills

Direct seeding by drilling method is done on prepared furrows by seed drill machine. Precision equipment, such as the multi crop seed drill with inclined plates, can also be used to drill seeds. Fertilizer can also be applied alongwith mechanised seed drillers. For uniform crop stand, smooth and levelled seedbed is necessary and seed should not be placed more than 10 to 15 mm depth.

Dibbling (Hill Planting)

If your land is unlevelled or slopy or where ploughing and harrowing is difficult, dibbling (hill planting) is to be done. With the help of long wood or bamboo pole attached with a metal scoop at the end dig holes, place seeds in the hole and cover it with soil.

Broadcasting without and with furrows

Drilling by hand or by seed drill

Dibbling on mountain slopes

Fig. 5.1: Different methods of direct seeding for dry soil

5.1.2 Direct Seeding Techniques for Wet Soil

In irrigated areas, direct wet seeding is done by placing the seed on well prepared wet field through broadcasting or drilling with drum seeder. Pre-germinated seeds are used for direct seeding on wet soil. Seeds should be soaked in water for 12 hours. After 12 hours, drain water and add seed treatment chemicals in wet seed. To get pre-germinated seed, the seeds should be kept in moist jute bags after treatment for 24 hours. Direct seeding onto wet soil can be done by following methods:

Broadcasting of Sprouted Seed on Puddle Soil

In direct seeding onto wet soil method, field should be prepared as for transplanted paddy. Seed is broadcasted onto well puddled seedbeds after draining water or in shallow standing water. If there is muddy condition in the field, allow the field to dry for 24 hours to settle soil particles before broadcasting. It will help in proper emergence of plant. Field should be irrigated 10 to 15 days after seeding or full emergence.

Fig. 5.2: Broadcasting pre-germinated seed

Seed Sowing by Drum Seeder in Puddled Soil

Drum seeder is manually operated implement used for direct seeding onto wet soil. Drum seeder works perfectly on a levelled, smooth and well puddled seedbed. This is a fast planting technique. A well trained operator is also required for seed sowing by drum seeder. Otherwise, uneven seeding may occur which leads to an uneven plant stand.

Drum seeder Drum seeding onto wet soil

Fig. 5.3: Drum seeder and seed drilling by drum seeder

5.1.3 Advantages and Disadvantages of Direct Seeding

Advantages

- Less labour is required for direct seeding rice because no need to prepare a nursery, uprooting the seedlings and transplanting.
- The crop of direct-seeded may mature 7 to 10 days earlier than transplanted.

Disadvantages

- Most of the time, the seeds are exposed to birds, rats and snails.
- Crop-weed competition is greater than transplanted rice because crop and weed both germinates at same time. However, if weeds are managed through weedicides just after sowing and within 35 days after sowing, it gives higher net profit among other methods.
- Higher seed requirement in direct seeded rice than transplanted rice.

INTEXT QUESTIONS 5.1

1. Seed requirement in direct seeded rice is ..... than transplanted rice.
2. Precision equipment for seed drilling in direct seeding rice onto dry soil is .....
3. On unlevelled or mountain slopes ..... method of direct seeding is used.
4. ..... are a big problem for direct seeded rice.

Notes

5.2 IMPROVED METHOD FOR TRANSPLANTED PADDY

System of Rice Intensification (SRI)

System of Rice Intensification, also known as SRI was developed in Medagaskar in the year 1983 by Father Henery D. Lauleni. This technology could not get popularised to other countries till 1997 but presently, it is successfully adopting in 28 countries like, Indonesia, China, Thiland, Sri Lanka and Bangladesh. It has proved in trials that productivity of paddy increased in SRI. Fundamental difference in SRI and traditional paddy cultivation is nursery management, young seedling transplanting, one seedling on a hill, use of organic manure and weed control through Cono-weeder. Main components of SRI are as follows:

- Soil fertility management
- Transplanting technique
- Weed control through mechanical method
- Controlled and shallow irrigation at regular interval

5.2.1 Principles of SRI

Nutrient Management through Organic Manures

To fulfil the balance nutrients requirement, fully decomposed FYM @10-12 ton/ha should be used in field. This helps to improve physical and chemical properties of soil resulting in increased in water holding capacity of soil.

Low Seed Rate

7.5 kg seed is sufficient for nursery of one hectare transplanting area.

Use of 8-12 Days Old Seedling

8-12 days old seedlings (two leaves seedlings) is to be used for transplanting which have higher establishment rate, tillering capacity and root growth in soil.

Fig. 5.4: 10 days old seedlings along with soil

Notes

Transplanting One Seedling on a Hill

In this method of rice cultivation, one seedling on a hill is transplanted. Seedlings should be carefully uprooted with seed and soil and shallow transplanting should be done.

Transplanting Spacing

Seedlings should be planted at a spacing of 25×25 cm2 in square system. Transplanting spacing can be decided on the basis of soil and climatic condition.

Less Water Requirement

SRI technique requires less water. Irrigation should be done on the presence of heir line crecks whereas in traditional method water flooding is maintained.

Inter-Culture

Weed control is done by mechanical method with the help of cono-weeder which turn weed into soil and improves soil aeration.

Insect and Disease

Insect and disease attack is less under paddy cultivation in SRI due to inter- culture through cono-weeder till 40 days from transplanting at 10 days interval.

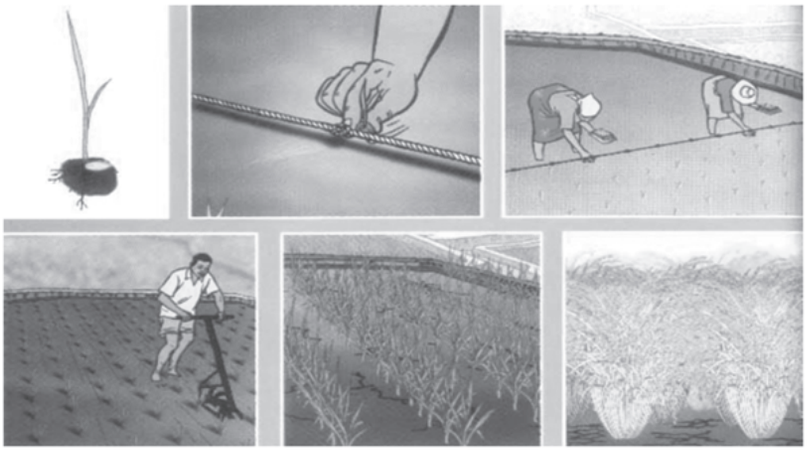


Fig. 5.5: Principles of SRI

5.2.2 Benefits of SRI

- Significantly higher yield (10-30%) is received in adoption of SRI technique due to more developed root, higher number of tillers and higher grains per panicle.
- Less input requirement, saving of seed and approximately upto 50% of irrigation water.
- About Rs.10,000.00 per hectare extra net return can be obtained in paddy cultivation through SRI than traditional cultivation technique.

Notes

5.2.3 Limitations and Prerequisites for SRI

- Dry season with assured irrigation is more suitable.
- Difficulty in crop establishment may be seen in areas with heavy downpour.
- Hybrids and varieties with heavy tillering are not suitable.
- Use 8-12 kg/ha seed for two seedlings per hill wherever difficulty in establishment of rice is seen.

5.2.4 Techniques For SRI

For increasing productivity of paddy and adoption of SRI technique, following techniques are important:

Suitability of Soil

Saline soil is not suitable for SRI as traditional paddy cultivation. Accumulation of salts on soil surface due to drainage in saline soils is harmful for short age seedlings and their roots. Medium to heavy with optimum organic carbon, levelled and well drained soils are suitable for system of rice intensification.

Nutrient Management

Use of Farm Yard and green manure creates favourable condition for crop production in SRI method. In this system, organic manures should be applied along with chemical fertilizers. Apply 10-12 ton/ha farm yard manure or any other manure and 40-50 tons of pond soil per hectare after 3-4 years.

Use of green manure is beneficial for balance fertilization point of view. Apply 100 kg/ha DAP at the time of Sesbania (Dhaincha) green manure sowing and turn it down into soil through harrow after 35 -40 days of sowing and apply 25 kg urea/ha for proper decomposition**.** It takes about 10 days for decomposition, and nursery seed sowing should be done at the time of green manure turning so that seedling will ready for transplanting at right time. Application of organic and green manure improves soil fertility, micro-nutrients status, water holding capacity and aeration in soil.

Nursery Management

Read lesson 3 for detailed information.

Field Preparation

Field preparation for transplanting in SRI should be done as in traditional method of paddy cultivation but land levelling is integral part for field preparation. Levelling is very much essential before transplanting for running marker to make a mark and to avoid water flooding. Irrigation water is evenly distributed in levelled field. Proper management of drainage should be done in starting and middle stage of growth after transplanting because flooding may create hindrance in extra tillering. Puddling should be done after levelling and one day prior to transplanting. It will help to settle clay particle.

Notes

Use of Marker

Marker or rope is used for making mark to maintain equal spacing in square planting. For this purpose, generally wood or iron is used. Marker has facility of 8 lines for making marks at 25×25 cm^2 spacing. Marker is used in well prepared field after puddling. Roller marker is more efficient, easy to run and mostly in use. One feet gap should be kept after every 4 or 8 lines for water drainage and other cultural operations.

Fig. 5.6: Use of marker

Transplanting

In this system 8-12 days old seedlings of 2-3 leaves is to be transplanted at 25×25 cm^2 spacing and 2-3 cm depth. One seedling on a hill along with soil and seed coat should be planted in well prepared unflooded field on square mark at proper distance. Seedling should be planted on shallow depth with the help of thumb and index finger. Efforts should be for planting within 15-30 minutes after seedling uprooting. In SRI technology, 16 hills should be kept in one square meter.

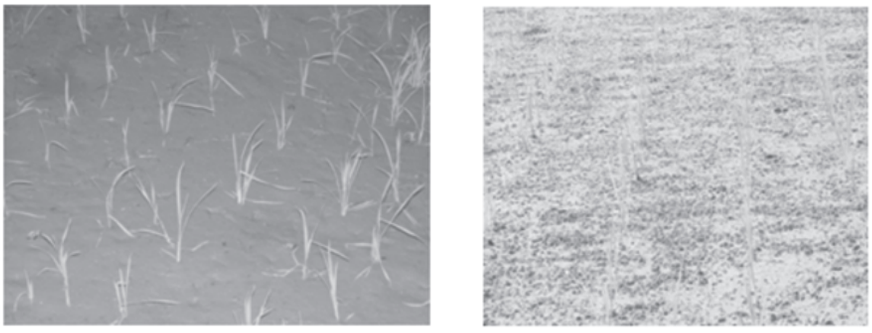


Fig. 5.7: Square transplanting (25 × 25 cm^2)

Inter Culture and Weed Control

Paddy production in SRI depends on the good inter cultural operations. Weed control and soil aeration is essential for crop because weed population and growth is more in SRI technique due to unflooded condition. Weed control is done by mechanical methods 3-4 times at 10 days interval after transplanting till panicle emergence through rotary weeder or cono-weeder. Seedling must be planted at recommended spacing so that inter-culture implements can run easily. This operation should be done in proper moisture condition in soil.

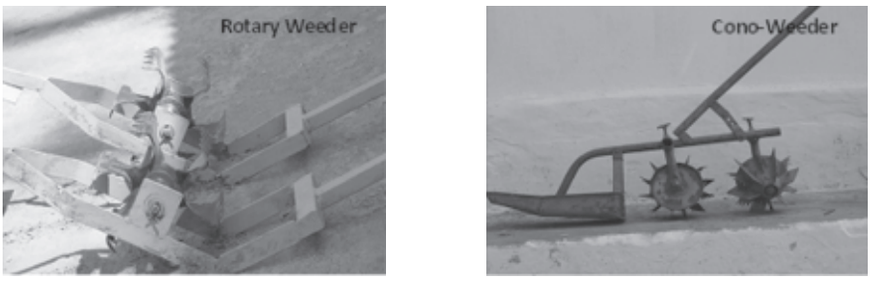


Fig. 5.8: Inter-culture implements

Inter culture operation through weeder is helpful for turning top dressed fertilizer into soil and make the soil friable which ultimately increase air movement in soil. By this process, activity of micro-organism and root growth increases.

Water Management

In general, it is understood that paddy uses higher amount of water and grow in standing water being semi-aquatic plant. Therefore, in traditional paddy production, water stagnation condition is maintained which is responsible for maximum water loss and decrease fertilizer use efficiency. In SRI method, soil moisture is maintained during initial and vegetative growth stage of crop. Irrigation is given on the appearing of hair line cracks in the field. Principally, having moist condition in soil creates aerobic ecosystem which does not harm the paddy roots. Irrigation should be given after drying of field at 3-7 days interval till tillering initiation stage of crop and on the completion of tillering, one inch water stagnation should be maintained. Water stagnation should not be maintained before15-20 days of maturity and at hardening of grains.

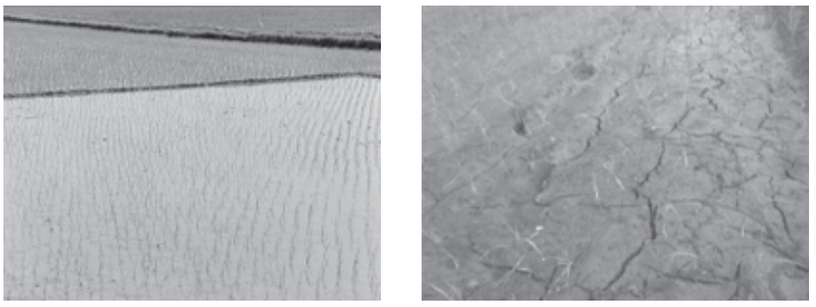


Fig. 5.9: Water management through less irrigation

Insect and Disease Management

Tolerance against the insect and disease is found in SRI paddy system. Although, insect and disease e.g. BPH, leaf folder, blast, sheath blight, attack is less under SRI method but in case of infection of disease and insect attack use biological tools such as *Trichoderma viride* or *Pseudomonas fluoresces* and *Trichogramma* cards. For precaution, seed treatment should be done through *Trichoderma viride* or *Pseudomonas fluoresces*@ 5-10 g/kg seed. Light and pheromone traps can also be used for insect control.

INTEXT QUESTIONS 5.2

Notes

1. Seed requirement for nursery of one hectare transplanting area in SRI technique is .....

   (a) 4.5kg (b) 5.5 kg

   (c) 6.5 kg (d) 7.5 kg

2. ..... days old seedling is used for transplanting in system of rice intensification.

   (a) 5 to7 (b) 8 to 12

   (c) 12 to 15 (d) 18 to 20

3. In SRI technique, seedlings should be planted at ..... cm^2 spacing.

   (a) 25×25 (b) 20×20

   (c) 15×15 (d) 10×10

4. Which one of the following implements is used for inter-culture operation in SRI.

   (a) Power Tiller (b) Harrow

   (c) Marker (d) Cono-weeder

WHAT HAVE YOU LEARNT

Let us recapitulate and enlist salient points we have learnt through this lesson:

- Different methods of direct seeding of paddy are used for various rice cultures e.g. rainfed low land, lowland rice culture under irrigated culture, deep water rice culture and upland rice culture.
- Broadcasting , drilling and seed dibbling method of direct seeding are used onto dry soil while broadcasting and seed drilling through drum seeder.
- Weeds are big problem for direct seeded rice. Weeds can be controlled effectively by stale seed bed, application of pre-emergence herbicides or by cono-weeder.
- Higher yield is reported in adoption of SRI technique due to more developed root, higher number of tillers and grains per panicle.
- In SRI technique, nursery preparation 100 m2 area and 7.5 kg seed is sufficient for planting one hectare area.
- Field preparation for transplanting in SRI should be done as in traditional method of paddy cultivation but land levelling is integral part for field preparation. In SRI technique 8-12 days old one seedling of 2-3 leaves is to be transplanted on a hill at 25 × 25 cm^2 spacing and at 2-3 cm depth. Marking is essential for maintaining proper distance.

- Weed control and inter-culture operation is done by mechanical methods 3-4 times at 10 days interval after transplanting till panicle emergence through rotary weeder or cono-weeder.
- In SRI method, soil moisture is maintained during initial and vegetative growth stage of crop. Irrigation should be given after drying of field at 3-7 days interval till tillering initiation stage of crop and on the completion of tillering, one inch water stagnation should be maintained.

TERMINAL EXERCISE

1. Explain the direct seeding techniques for dry soil.
2. In which conditions dibbling (hill planting) is done?
3. Explain the broadcasting of sprouted seed on puddle soil.
4. Discuss the direct seeding method onto wet soil.
5. Enlist the advantages and disadvantages of direct seeding.
6. Write down the main components of SRI.
7. Discuss the principle of SRI.
8. Write short note on the following
   (a) Nursery preparation for SRI
   (b) Transplanting in SRI
   (c) Benefits of SRI
   (d) Limitations and Prerequisites for SRI
9. Explain the nutrient management in SRI?

ANSWERS TO INTEXT QUESTIONS

5.1

1. More
2. Turbo Happy Seeder
3. Seed Dibbling
4. Weeds

5.2

1. (d) 7.5 kg
2. (b) 8 to12
3. (a) 25 × 25
4. (d) Cono-weeder

Notes

6

INTEGRATED NUTRIENT MANAGEMENT

We all are aware about the adverse effects of chemical fertilizers being used for enhancing crop production. These chemicals may cause underground water pollution, air pollution, acidification of the soil, mineral depletion of the soil, runoff of excessive fertilizers etc. Then, what's the solution? Shall we stop using these chemicals? Is this will affect our crop production? Let us learn about the Integrated approach of Nutrient management. Integrated Nutrient Management (INM) is increasingly advocated as an environment friendly alternative for nutrient management. Imbalance use of chemical fertilizers may deteriorate soil quality to a greater extent than the use of balanced fertilization on long term basis. Therefore, you need to apply suitable combination of organic, inorganic fertilizers and bio-fertilizer in right proportion for maintaining soil quality to ensure crop production on sustainable basis. The basic concept underlying INM is the maintenance of soil fertility, sustainable agricultural productivity and improving profitability through judicious and efficient use of fertilizers, organic manures, crop residues, bio fertilizers and suitable agro-chemical practices. The main components in INM besides inorganic fertilizers as the major component, include farmyard manure (FYM), composts, green manure, vermicompost, crop residues, bio fertilizers and crop rotation which can supplement 50% of the nitrogenous requirement of the crop.

OBJECTIVES

After reading this lesson you will be able to:

- discuss the concepts of INM in paddy;
- explain the components of INM;
- apply chemical fertilizers along with other natural resources judiciously;
- identify the deficiency/toxicity symptoms of various nutrients essential for paddy crop.

Notes

6.1 INTEGRATED NUTRIENT MANAGEMENT PRACTICES IN PADDY

Integrated nutrient management (INM) aims at maintenance or adjustment of soil fertility and of plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of benefit from all possible sources of plant nutrients in an integrated manner.

Organic sources used in paddy production includes Farm Yard Manure (FYM), composts, green manure, quick growing leguminous crops grown in the cropping sequence, biofertilizers (blue green algae and azolla). Enlist the organic fertilizers you are using in your field:

S.No.	Organic fertilizers	Used in crop

6.1.1 Organic Manure

You may also apply bulky organic manure to maintain the physical condition of the soil and also to increase the water holding capacity of the soil.

Apply 10-15 tonnes of well rotted FYM or compost in one hectare area 25-30 days before transplanting. Spread all the manure evenly on the field and plough to get it well mixed in the soil.

6.1.2 Green Manuring in Paddy

Green undecomposed leafy material used as manure is called green manure. You may obtain green manures by two ways:

- By growing green manure crops, or
- By collecting green leaf (along with twigs) from plants grown in wastelands.

The crops that are grown for green manure are known as green manure crops. The most important leguminous crops that can be used as green manure in paddy crop are green gram, sunnhemp, dhaincha (*Sesbania aculeate*), *pillipesara*, clusterbean, *Sesbania rostrata*, cowpea, salsaboal etc. Green manure improves the nutrient use efficiency of the crop by increasing organic matter in soil.

Table 6.1: Biomass production and Nitrogen (N) accumulation in green manure crops

Crop	Age (Days)	Dry matter (t/ha)	N_2 accumulated
Sesbania aculeata	60	23.2	133
Sunnhemp	60	30.6	134
Cow pea	60	23.2	74
Pillipesara	60	25.0	102
Cluster bean	50	3.2	91
Sesbania rostrata	50	5.0	96

You can grow the above crops in field during April and incorporate in field after 50-60 days i.e. 15 days before transplanting of the paddy seedlings.

Fig. 6.1: Green manure crops for paddy

6.1.3 Bio-fertilizers

These are the preparations containing living cells or latent cells of efficient strains of microorganisms that help crop plants uptake of nutrients by their interactions in the rhizosphere when applied through seed or soil. Biological nitrogen fixation in soil occurs through medium of bacteria which convert atmospheric nitrogen to the plant available nitrogen form freely or in symbiosis with leguminous crops, trees or shrubs or with Azolla

Notes

in wetland conditions. These are eco-friendly and environmentally safe. The biofertilizers used for paddy crop are Azospirillum, Phosphobacteria, Blue green algae, Azolla and Mycorhiza.

Azospirillum

It is an associative symbiotic bacterium used as an important biofertilizer in paddy for nitrogen fixation. Azospirillum also solubilizes phosphorus and silicon to some extent required by paddy. Azospirillum is recommended for seed and seedlings treatment and applied in main field as given below:

(i) **Seed treatment:** 600 g/ha of Azospirillum culture are to be mixed with water and soaked the seeds for one night before sowing in the nursery bed.

(ii) **Seedling treatment:** Slurry can be prepared by mixing Azospirillum @1000 g/ha in 40 litres of water and root portion of paddy seedlings are dipped in bacterial suspension for 15-30 minutes and then they are transplanted.

(iii) **Main field:** 2000 g/ha of Azospirillum with 25 kg farmyard manure and 25 kg of soil are mixed uniformly and broadcasted in the main field before transplanting.

Blue Green Algae (BGA)

BGA is another type of biofertilizer used as an algal form. Important species are Cyanobacteria, Anabaena, Nostoc and Tolypothrix. Blue green algae occur naturally and come up well under moist conditions. This can also be artificially cultured.

Method of Inoculation of BGA in Rice Field

You may apply Blue Green Algae as soil based inoculum to the paddy field. Follow the steps as described below:

- Powder the soil based algal flakes very well.
- Mix it with 10 kg soil or sand (10kg powdered algal flakes with 10 kg soil / sand).
- BGA is to be inoculated on 7-10 days after rice transplanting.
- Water level at 3-4″ is to be maintained at the time of BGA inoculation and then for a month for maximum BGA development.

Azolla

Azolla is a free floating fresh water fern. *Azolla pinnata* is the most common species occurring in India. It fixes nitrogen due to Anabaena species of blue-green algae present in the lobes of Azolla leaves. A thick mat of Azolla supplies 30 to 40 kg N/ha.

Multiplication of Azolla

Azolla can be mass multiplied by constructing nurseries with 10 cm deep standing water and adding super phosphate @ 8 kg P_2O_5/ha in small plots. Inoculation can be done @

Notes

8 kg/m^2. Raise Azolla as a dual crop by inoculating 250 kg/ha at 3 - 5 Days After Transplanting (DAT) and then incorporate during weeding for the wet season crop. It can be applied as green manure prior to paddy planting or can be grown as dual crop with paddy. About 10 tonnes of fresh Azolla per hectare is equivalent to 30 kg nitrogen/ha.

Phosphobacteria

This type of bio-fertilizer solubilises phosphate in the soil and renders them in available form for crop plants. It can be applied for low land and upland paddy. This is applied as the same dose and same manner as Azospirillum. Bacteria like *Bacillus megatherium* var. phosphaticum, *pseudomonas*, *fluorscens*, fungi like *Pencillium digitatum, Aspergillus niger* were found to have a strong phosphate dissolving ability. Mix 10 packets (2 kg/ha) each of Azospirillum and Phosphobacteria or 10 packets (2 kg/ha) of Azophos inoculants with 25 kg FYM and 25 kg of soil and broadcast the mixture uniformly in the main field before transplanting. *Pseudomonas fluorescens* (Pf 1) @ 2.5 kg/ha mixed with 50 kg FYM and 25 kg of soil and broadcast the mixture uniformly before transplanting.

Since, biofertilizers are ecofriendly inputs and are safer to the environment, you should adopt them and get benefited.

6.2 APPLICATION OF NUTRIENTS ON THE BASIS OF SOIL TESTING

Chemical fertilizers are rich in plant nutrient and required in very less quantity to supply equal amount of nutrients from organic sources. You should plan the chemical fertilizers application on the following basis:

(i) Fertility status of the field.

(ii) Previous crop grown.

(iii) Amount of organic manure applied.

Before deciding the fertilizer dose, go for soil testing to know the status of the nitrogen, phosphorus and potassium in the soil. After testing the soil, calculate the fertilizer dose accordingly.

6.2.1 Soil Testing

For sustainable crop production, assessment of soil fertility and making fertilizer prescriptions is very important. Soil testing is an essential component for identifying the nutrient requirement of soil. For soil testing collect the soil sample from the field which should be representative of the area being sampled. In general, sampling is done at the rate of one sample for a homogenous plot of one hectare.

6.2.2 Method of soil sampling

Collect the soil sample with the help of auger or khurpi up to 30 cm depth just after harvesting of the crop grown before paddy at 7-10 spots in a *zig-zag* pattern to ensure

Notes

homogeneity. The sample should be taken by V shaped digging of the soil profile. The sampling should be avoided from dead furrows, wet areas, areas near manure heaps, bunds, irrigation channels and under the shade of trees. Mix the sample soil thoroughly and remove foreign materials like roots, stones, pebbles and gravels. Reduce the bulk to about half to one kilogram by quartering. Collect the sample in a clean cloth or polythene bag. Label the bag with information like name of the farmer, location of the farm, survey number, previous crop grown, present crop, crop to be grown in the next season, date of collection, name of the sampler etc. and send for laboratory analysis.

Soil test based recommendations will be useful only when it is based on important factors like soil, crop, variety, fertilizer and management interaction for a given soil condition.

6.3 INORGANIC FERTILIZER APPLICATION

However, in the absence of soil test, apply fertilizers according to the following general schedule:

- For short duration varieties: Nitrogen (N)- Phosphorus(P)- Potassium (K) @ 120-40-40 kg/ha.
    - For medium duration varieties: NPK @ 150-50-60 kg/ha.
    - For long duration varieties: NPK @ 150-50-80 kg/ha.
- Apply full dose of phosphorus, potash and zinc at transplanting.
- Apply nitrogen in 4 equal splits viz., basal, tillering, panicle initiation and heading stages. Tillering and panicle initiation periods are crucial and should not be reduced with the recommended quantity.
- Apply Nitrogen in ammonical forms through fertilizers like urea.
- Avoid standing water in the field at the time of application of nitrogenous fertilizer.
- Application of zinc along with N had synergistic effect on N and Zn uptake in paddy. Apply 25 kg of zinc sulphate/ha mixed with 50 kg dry sand at friable moisture, just before transplanting.

Table 6.2: Phonological stages of paddy (days after sowing) for split nitrogen application

Stages	Varieties		
	Short duration (105 days)	**Medium duration (135 days)**	**Long duration (150 days)**
Active tillering (AT)	35-40	50-55	55-60
Panicle initiation (PI)	45-50	70-75	85-90
Heading (H)	70-75	100-105	115-120

Notes

INTEXT QUESTIONS 6.1

1. Organic source of nutrients is

   (a) Urea (b) DAP (c) Farmyard manure

2. In paddy Zn should be applied at the rate of Kg/ha.

   (a) 50 (b) 10 (c) 25

3. Which stage of paddy is most crucial for N fertilizer application?

   (a) Tillering and Panicle initiation periods

   (b) Basal (c) Heading stage

4. From one hectare area how many soil sample should be taken?

   (a) 5 (b) 2 (c) 1

6.4 NUTRIENT DEFICIENCY SYMPTOMS IN PADDY

Have you ever noticed deficiency or toxicity symptoms in any crop? Actually, the symptoms of nutrient deficiency or toxicity are not always readily apparent in a growing crop. In paddy, most common nutrients which show deficiency symptoms are nitrogen, potassium, zinc and iron. Once deficiency symptom is identified, it may be corrected through application of respective nutrient. Deficiency symptoms of nutrients affecting the paddy crop are as follows:

Nitrogen (N)

The loss of N from chloroplasts will result in yellowing of older leaves while new leaves remain green as nitrogen is highly mobile in nature. Plant becomes stunted and discoloured. Older leaves or whole plants are yellowish green and chlorotic at the tip in case of severe deficiency. It causes poor root growth and young plants give spindly appearance, leaf chlorosis (Fig 6.2).

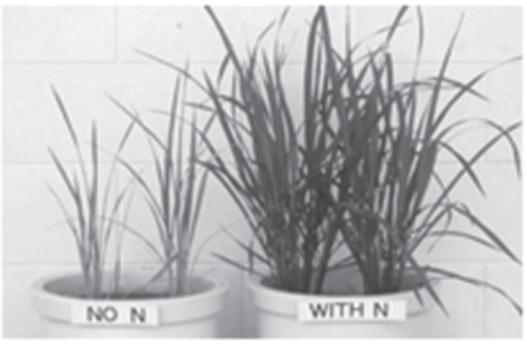


Fig 6.2: Paddy plant deficient in nitrogen

Notes

Potassium (K)

Potassium deficient plant leads to stunted dark green plants with yellowish brown leaf margins and/or older leaves with necrotic tips and margins. Leaf symptoms of K deficiency can be confused with that of tungro disease, but tungro occurs in patches in a field (not in the whole field) and usually has more pronounced yellow and orange leaves and plant stunting; leaf symptoms often appear in late growth stages; unhealthy or black roots; greater lodging; higher level of unfilled grains; lower grain weight (Fig 6.3).

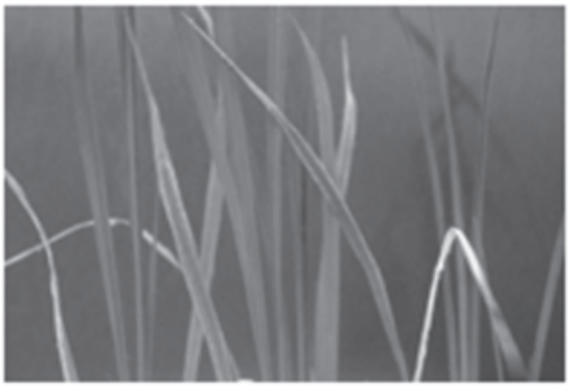


Fig: 6.3: Paddy plant showing potassium deficiency

Zinc (Zn)

Zinc deficiency is most common disorder of lowland paddy and mainly occurs on middle-aged leaves. The growth of the plant stunted. Dusty brown spots appear on leaves of stunted plants, tillering reduced, with uneven plant growth and patches of poorly established hills. Brown blotches and streaks appeared on older leaves. Under severe deficiency, tillering decreases and time to crop maturity may be increased (Fig 6.4).

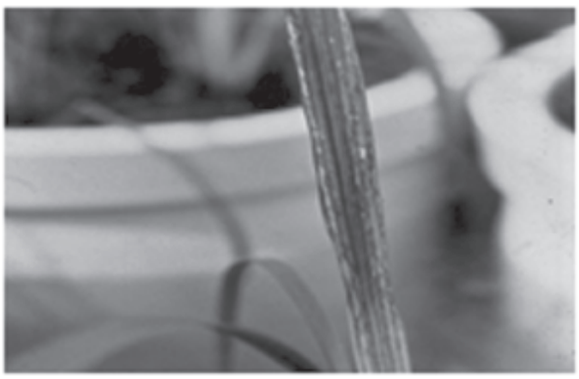


Fig. 6.4: Paddy plant deficent in Zinc

Iron (Fe)

Iron deficiency causes chlorosis in terminal leaves. Interveinal yellowing and chlorosis of emerging leaves, whole leaves become chlorotic and then very pale. Entire plant becomes chlorotic and dies. If deficiency is very severe, it decreases dry matter production and

Notes

causes smelling of leaves and leaf abscission. Mild N deficiency can be confused with Fe deficiency, but the later affects the emerging leaf first (Fig 6.5).

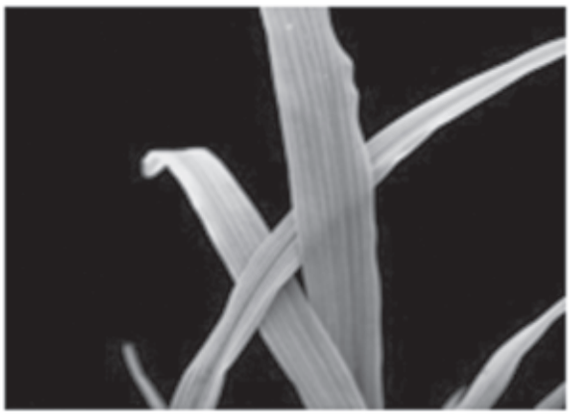


Fig. 6.5: Paddy deficent in Iron

INTEXT QUESTIONS 6.2

1. Nitrogen deficiency symptoms occur on

   (a) Older leaves (b) New leaves (c) Middle leaves

2. Inter-veinal yellowing and chlorosis of emerging leaves occur because deficiency of

   (a) Zn (b) Fe (c) N

3. Yellowing of middle-aged leaves is symptom of

   (a) Zn deficiency (b) Zn deficiency (c) Fe deficiency

WHAT YOU HAVE LEARNT

Let us recapitulate and enlist salient points we have learnt through this lesson:

- Integrated nutrient management (INM) is essential for maintaining soil fertility and for plant nutrient supply to an optimum level for sustaining the crop productivity through a balanced use of fertilizers combined with organic and biological sources of plant nutrients.
- Organic sources used in paddy production includes organic manures like FYM, vermicompost, composts, green manure, quick growing leguminous shrubs grown in the cropping sequence, biofertilizers etc. which can supplement 50% of the nitrogenous requirement of the crop.
- Nitrogen is applied to paddy crop in 4 equal splits viz., at basal, tillering, panicle initiation and heading stages. Tillering and panicle initiation periods are critical and should not be reduced with the recommended doses.

Notes

- Use of bio-fertilizers viz. *Azospirillum*, Phosphobacteria, Blue green algae and Azolla increases the availability of nutrients in paddy fields.
- Nitrogen deficiency symptoms occur on older leaves (yellowing) and Iron (Fe) deficiency symptoms occur on new or terminal leaves (yellowing on tips & interveinal yellowing and chlorosis).
- Micronutrient Zn is deficient in most of the paddy growing belts. Basal as well as spray of Zinc is recommended to control zinc deficiency.

TERMINAL EXERCISE

1. Describe INM and its different components.
2. What is the green manure? Explain different types of manure used in paddy field.
3. Explain bio-fertilizer application in paddy field.
4. Explain the inorganic fertilizer application procedure.
5. Describe the method of soil sampling.
6. How will you correct the deficiency of Zn in paddy field?

ANSWERS TO INTEXT QUESTIONS

6.1

1. (c) Farmyard manure
2. (c) 25
3. (a) Tillering and panicle initiation periods
4. (c) 1

6.2

1. (a) Older leaves
2. (b) Fe
3. (b) Zn deficiency

7

WATER MANAGEMENT

Paddy cultivation at present dominates irrigated agriculture. Adequate water supply is one of the most important factors in paddy production. In many parts of the tropical regions, paddy plant suffers either from too much or too less water because of irregular rainfall and landscape patterns. Water management facilitates the control of water for optimum crop yield and the best use of limited supply of water. Proper management of water and irrigation system is essential, especially for those that based on stored water, enables a water supply during dry season.

OBJECTIVES

After reading this lesson, you will be able to:

- explain the role of water for crop production;
- discuss the effect of flooding;
- manage water for paddy cultivation for wet and dry conditions;
- identify the critical stages for paddy irrigation.

7.1 ROLE OF WATER FOR CROP PRODUCTION

Water plays an important role in day to day life. Approximately 70% of the freshwater used by humans goes to agriculture. Following are the significant role of water in crop production:

- Water is main constituent of protoplasm; approximately 80-90%. Cell division is not possible without water, therefore plant development depends upon water availability.
- Germination of seed is not possible without sufficient moisture in the soil.

Notes

- Plants take their nutrients from the soil in liquid form which enables its translocation to every part.
- Water provides the required turgidity to cells and controls cell temperature which helps the crop to overcome excess temperature and frost.
- The vital process of photosynthesis involves transformations of water and carbon-dioxide to carbohydrates through chlorophyll in the presence of sunlight.
- Water helps in tillage operations and timely sowing of the crops.
- Water helps in an increased activity of useful organisms and chemical processes of soil.

7.2 EFFECT OF FLOODING/SUBMERGENCE

Generally, paddy field is kept flooded by water throughout crop growth period. Paddy is typically grown in bunded fields that are continuously flooded up to 7-10 days before harvest. Flooding the paddy field is having both advantages and disadvantages as follows:

Advantages of Continuous Submergence

- Less weed problem.
- Fixation of nitrogen by blue green algae.
- Increased availability of nutrients such as Phosphorus (P), Iron (Fe), Manganese (Mn), Zinc (Zn) and Silicon (Si).
- Regulation of soil temperature.
- Reduction in labour cost.

Disadvantages of Continuous Submergence

- Deep percolation losses of irrigation water.
- Surface runoff losses of irrigation water.
- Leaching of nutrients particularly nitrogen.
- Sulphide injury.
- Iron toxicity.

Submergence versus Saturation

In most areas paddy fields are submerged continuously throughout the crop growing period, but it's not always essential. Studies have indicated that soil saturation is sufficient for *kharif* rice, while submergence not exceeding 5 cm seems to be essential and adequate for *rabi* rice.

INTEXT QUESTIONS 7.1

Notes

1. The Protoplasm contains ..... % water.
2. Continuous submergence decreases ..... problem.
3. Flooding increases the ..... fixation by blue green algae.
4. Higher temperature ..... evaporation of water.
5. Saturated or flooded condition can be maintained under ..... percolation rates.

7.3 WATER LOSS FROM PADDY FIELDS

We all are aware that paddy is a semi-aquatic plant and requires more water than other crops. Water to produce optimum yields of paddy must satisfy the evapotranspiration needs of the crop and losses from the paddy field through percolation and seepage. The amount of water required varies with the growth duration of the paddy variety, type of soil, topography (lowland or upland) of land and establishment method. Moisture loss from paddy may be grouped into vapour and liquid form. These losses can be further divided as:

1. loss by transpiration from the leaf surface,
2. loss by evaporation at the water surface,
3. surface drainage, and
4. liquid loss occurs as downward movement as percolation and lateral movement from surface soil and upper subsoil as seepage.

Percolation losses are the major loss of water from paddy field and it is a function of the local soil and topographic conditions. Therefore, at any time the amount of rainfall or irrigation water entering the soil becomes greater than its water holding capacity, losses by downward movement of free water (vertical percolation) will occur. Percolation is often defined as the movement of water through saturated soils due to gravity, hydrostatic pressure or both. It is estimated that about 50 to 60% of applied water to paddy crop is lost by deep percolation.

The percolation losses can be reduced by adopting following agronomic practices:

1. Growing rice on clayey soils
2. Land levelling to zero slope with laser land leveller
3. Shallow depth of submergence
4. Sub-soil compaction through puddling

Notes

7.4 EFFECT OF WATER USE AND MOISTURE STRESS ON GROWTH STAGES

The water use and moisture stress effects vary at different growth stages of paddy. Sufficient moisture supply is more critical in some growth stages than others. Moisture stress reduces crop yield when it occurs during the critical growth stages.

Table 7.1: Optimum depth of submergence in rice field:

S. No.	Crop growth stage	Depth of submergence
1.	At transplanting	2 cm
2.	After transplanting for 3 days	5 cm
3.	3 days after transplanting to maximum tillering	2cm
4.	At maximum tillering (midseason drainage)	Drain water for 3 days
5.	Maximum tillering to panicle initiation	2 cm
6.	Panicle initiation to 21 days after flowering	5 cm
7.	After 21 days after flowering	Drain out water gradually

The **Critical Stages** for irrigation in paddy crop are:

1. Seedling stage/ transplanting stage
2. Tillering stage
3. Panicle initiation stage
4. Flowering stage
5. Milky stage

7.5 WATER REQUIREMENT IN PADDY

Total water requirement refers to water needed to raise seedlings, prepare land and to grow a crop of paddy from transplanting/ seed sowing to harvest. On an average, it takes approximately 1,400 litres of water to produce 1 kg of paddy in an irrigated lowland production system. Total seasonal water input to paddy fields varies from as little as 400 mm in heavy clay soils with shallow groundwater tables to more than 2000 mm in coarse-textured (sandy or loamy) soils with deep groundwater tables. Around 1300-1500 mm is a typical amount of water needed for irrigated paddy in Asia. The amount of water requirement depends on:

Notes

(i) Soil type

(ii) Topography

(iii) Proximity to drain

(iv) Depth of water table

(v) Area of adjacent paddy field

(vi) Fertility of soil

(vii) Duration of crop

(viii) Land preparation method

(ix) Method of crop establishment

(x) Evaporative demand of the growing season

Raising Seedlings

It is estimated that 150-200 mm of water is required for nursery bed preparation and 250-400 mm is required to raise seedling of 25-40 days a period generally used by farmers.

Land Preparation

The amount of water needed to prepare land depends mainly on soil type and water holding capacity, but most importantly on type of land preparation. Water is used 1-2 days before ploughing (pre-sowing irrigation) to moisten the soil for easy working. Approximately, 200 mm of water is commonly used for land preparation and initial flooding. Puddling operation increases the amount of water used by a paddy crop for land preparation.

Field Irrigation

Paddy plants require a large amount of water after transplanting. Crop duration from transplanting to crop maturity is generally 90-120 days. The amount of water required in the field depends on the water depth maintained, water management practices, soil types and evaporative demand. Water requirement in the field from transplanting to harvest is between 800 to 1200 mm, with a daily consumption of 6 -10 mm.

7.6 WATER MANAGEMENT PRACTICES FOR CROPPING SYSTEM

With increased demand for all food crops, particularly paddy, there is a need of concentrated efforts to increase total food production. One of the ways to achieve this is by increasing cropping intensity. Good water management is the primary requirement for increasing cropping intensity.

Notes

Continuous Paddy Cropping

When adequate and assured water supply is available, continuous paddy cropping with at least three crops a year is possible where favourable temperature prevails. Yields on continually shallow flooded fields were similar to those on continually flooded at 10 cm depth. Maintaining continuous flooding with 5-7.5 cm of water is probably best for continuous cropping of irrigated paddy.

Paddy Based Cropping System

Continuous year–round paddy cropping is undesirable even under adequate water supply. The inclusion of other crop in rotation with paddy increases nutritional and economic benefits and decreases paddy pest pressure. The furrow irrigation in paddy on non puddled soil is desirable alternative to soil puddling for paddy cultivation in heavy textured soils of uplands. More than one third of the water involved in Evapo-transpiration (ET) is from the surface of the standing water in a paddy field. Therefore, the practice of furrow irrigation in non puddled soil might lower the requirement of irrigation water. Maintaining the soil in a non puddled or dry land condition allows the other crop insertion into a rotation.

7.7 WATER MANAGEMENT PRACTICES FOR DIFFERENT ESTABLISHMENT TECHNIQUES

In most of the part of Asian tropics, paddy is primarily transplanted and in some part paddy is broadcast-seeded either in dry soil or a wet or moist soil. Different crop establishment methods require different water management practices. Seeding into standing water is not in common practice because lack of water control and low oxygen in water at high temperature leads to poor stand establishment.

7.7.1 Direct Seeded Rice (DSR)

The direct-seeded rice system widely depends on method of seeding, soil type, climatic condition, crop rotation, disease and insects. There are two broad system of water management related to seeding method:

(a) Drill seeding or broadcasting in dry soil and

(b) Seeding in *vattar* (irrigated) condition.

Under *vattar* DSR, first irrigation may be applied at 7-15 days. The follow up irrigation should be applied at weekly interval. Under Dry direct seeded rice immediately followed by irrigation, subsequent irrigation should be applied at 4-5 DAS to ensure uniform germination and avoid seedling mortality. The follow up irrigations should be applied at weekly interval. Care should be taken for no water stress at critical stages for irrigation.

7.7.2 Transplanted Rice

Puddling and levelling in transplanted rice reduces the loss of water through percolation and excess depth of water.

For Continuous Flooding

Continuous flooding of water generally provides the best growth environment for paddy. After transplanting, water levels should be around 3 cm initially, and gradually increase to 5-10 cm (with increasing plant height) and remain there until the field is drained 7-10 days before harvest.

For Alternate Wetting and Drying

Alternate Wetting and Drying (AWD) can be started a few weeks (1-2) after transplanting. Irrigate and then allow the water depth to drop to 15 cm below the surface using a field water tube (Fig.7.1) to monitor the water level depth. Once the water level has dropped to 15 cm below the surface, re-flood the field to a depth of 5 cm above the surface and repeat. From one week before to one week after flowering, the field should remain flooded. At flowering, during grain filling and ripening, the water level can drop to 15 cm below the surface before re-flooding. When many weeds are present, AWD should be done for next 2-3 weeks. This will suppress weeds and improve herbicide efficacy.

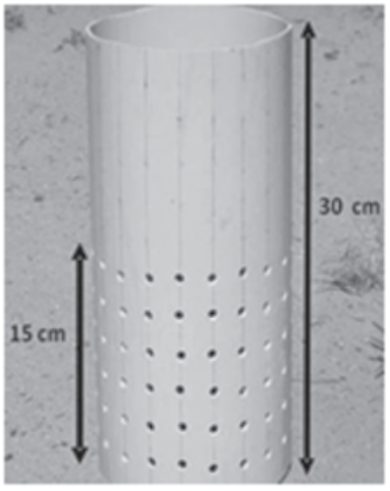


Fig. 7.1: Field water tube

7.6 QUALITY OF IRRIGATION WATER

It is important to determine water quality before it is used for irrigation. It is important to test the water quality periodically to reduce the chance of potential hazards of crop damage by poor quality irrigation water. If ground water containing high levels of sodium, used for continuous irrigation in paddy field may cause chlorosis and sometimes death of seedlings and after some years, it may also deflocculates the soil. Good quality water for paddy irrigation should have following characters:

- Specific conductance less than 0.75 mmhos/cm.
- Boron contents less than 1 ppm.
- Sodium adsorption ratio index less than 10.

Notes

INTEXT QUESTIONS 7.3

1. To produce 1 kg of paddy in an irrigated lowland production system, approximate ..... litres of water will required.

   (a) 1000 (b) 1200

   (c) 1400 (d) 1600

2. Water requirement from transplanting to harvest is between ..... mm, in the field with a daily consumption of 6 -10 mm.

   (a) 400 to 800 (b) 800 to 1200

   (c) 1200 to 1600 (d) 1600 to 2000

3. Continuous flooding with ..... cm depth of water is best for continuous cropping of irrigated paddy.

   (a) 0.5-7.5 (b) 7.5-10.0

   (c) 10-15 (d) >15

4. Boron content in good quality irrigation water should be

   (a) 6-8 ppm (b) 4-6 ppm

   (c) 2-4 ppm (d) <1 ppm

WHAT YOU HAVE LEARNT

Let us recapitulate and enlist salient points we have learnt through this lesson:

- Paddy is a semi-aquatic plant; it requires more water than most of the other crop because of different types of losses. Water to produce optimum yields of paddy must satisfy the evapotranspiration needs of the crop in vapour form and losses from the paddy field through percolation and seepage as liquid loss.
- Water use and moisture stress effects vary at different growth stages of paddy. Sufficient moisture supply is more critical in some growth stages than others.
- Moisture stress reduces crop yield if it occurs during critical growth stages.
- Different crop establishment methods require different water management practices. Seeding into standing water is not in common practice because of lack of water control and low oxygen in water at high temperature which leads to poor stand establishment.
- In dry seeded direct seeding, seed is drilled in dry soil and first flooding may be done as paddy is emerging or it may be delayed for 2-3 weeks depending on growing condition.

Notes

- In transplanted paddy, water levels should be around 3 cm initially, and gradually increase to 5-10 cm (with increasing plant height) and remain there until the field is drained 7-10 days before harvest. Alternate Wetting and Drying (AWD) can be started a few weeks (1-2) after transplanting under water scarcity.

TERMINAL EXERCISE

1. Describe the effect of flooding on paddy crop.
2. Write the short note on following terms related to water loss in paddy:

   (a) Transpiration (b) Evaporation (c) Percolation
3. What are the critical stages for irrigation in paddy?
4. Explain the irrigation management for Direct Seeded Rice.
5. Explain Alternate Wetting and Drying method of water management in paddy.

ANSWERS TO INTEXT QUESTIONS

7.1

1. 80-90
2. weed
3. nitrogen
4. increases
5. low

7.2

1. (c) (1400)
2. (b) (800 to 1200)
3. (a) (0.5-7.5)
4. (d) (<1 ppm)

Notes

8

INTEGRATED WEED MANAGEMENT

Weeds are the plants, which grow where they are not wanted (Jethro Tull, 1731). Weeds can also be referred to as plants out of place. Weeds are unwanted or undesirable plants which compete with crops for water, soil nutrients, light and space and thus reduces crop yield.

Weed management is the application of certain principles and suitable methods to control weeds that will improve the vigor and uniform stand of the crop. The weed can be managed by a System approach called as Integrated Weed Management. The Integrated Weed Management (IWM) is a system which brings all feasible methods of weed control harmonizing them into a single and coordinated system designed to maintain weeds below threshold level or those levels above which they cause economic loss.

Rice is grown in direct and transplanted conditions. Weed competition is more in direct seeded rice. Reduction in yield to the tune of 34% in transplanted rice, 45% in direct seeded low land rice and 67% in upland rice are reported. Weed competition in direct seeded rice is greatest during the first three weeks. The critical period for weed free condition for higher productivity is reported to be 30-35 days in transplanted rice where as in direct seeded low land and upland condition it ranges from 40-60 days.

Proper weed management technologies if adapted can result in an additional rice production. Thus weed management would continue to play a key role to meet the growing food demands of increasing population in India. In this context, Integrated Weed Management (IWM) may provide a more sustainable approach to rice production.

OBJECTIVES

After reading this lesson you will be able to:

- identify the major weeds of paddy crop;
- manage the weed population through an integrated approach.

Notes

8.1 MAJOR WEEDS OF PADDY

The morphological classification is most important and useful in weed control. Morphological characters of plant are closely related to herbicidal absorption, retention, & translocation. Weeds belonging to the same group are likely to have same kind of response to specific herbicides or cultural or mechanical methods. This is the most widely used classification by the weed scientists. So, the weeds of rice crop are generally categorized in three groups i.e. grasses, broad leaved weed and nut sedges.

8.1.1 Grassy Weeds

The most common grassy weeds present in paddy fields are as given below:

1. **Barnyard grass** (*Echinochloa crusgalli*): It belongs to Poaceae family and commonly known as Barta or Sanvak. It is an annual grass, resemble with paddy plant but color is lighter than paddy and propagate through seed. A single plant produces 30,000-40,000 seeds.

2. **Jangli Rice** (*Echinochloa colonam*): It belongs to Poaceae family and commonly known as Chhota Sanvak Samak. It is also similar to paddy plant and propagated through seed. The stems are hard with purple color base.

3. **Egyptian crowfoot grass** (*Dactyloctenium aegyptium*): Belongs to Poaceae family and commonly known as Makda. It is an annual grass, propagated through stem nodes. The stems are branched having 15-60 cm long and the flowers are like crow feet.

4. **Chinese Sprangaltop** (*Laptochloa chinensis*): It is an annual weed which belongs to Poaceae family. It is propagated through seeds and flowers are in panicle shape of upto 40 cm long.

5. **Japani Lovgrass** (*Eragrostis japonica*): Annual weed of Poaceae family which is propagated through stem nodes. The stems are hollow and leaf sheath possess hairs and ligules. It is mainly an upland weed and found in rice and sugarcane.

6. **Indian Lovgrass** (*Eragrostis pilosa* tenella): Annual weeds of Poaceae family which is propagated through seeds. The stems are stiff, thin and having nodes and flowers are loose.

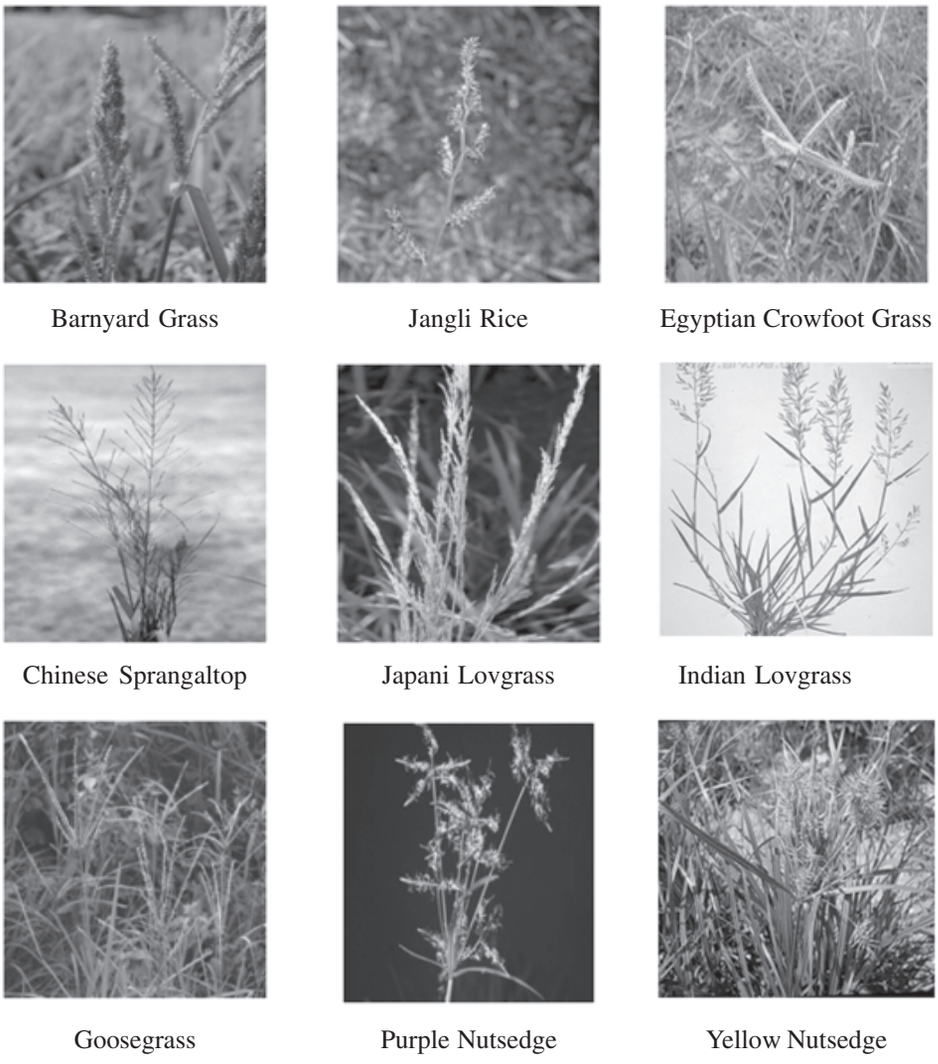
7. **Goosegrass** (*Eleusine indica*): Annual weeds of family Poaceae. It spreads on ground like mat. The spikelets looks like fingers of hand.

8.1.2 Nut Sedges

1. **Purple nut sedge** (*Cyperus rotundus*): Belongs to Cyperaceae family and commonly known as motha or dilla. It is a perennial weed with straight unbranched stems covered with leaves. This weed has allelopathic effect on crop. It grow mainly from tubers formed on horizontal, underground, creeping stems called rhizomes, mostly in the upper layer of soil.

Notes

2. **Yellow nut sedge** (*Cyperus iria*): Belongs to Cyperaceae family and commonly known as flat sedge or nagar motha. It is an annual weed with 20-70 cm height. The leaves are just below the yellow coloured flowers.



Barnyard Grass | Jangli Rice | Egyptian Crowfoot Grass

Chinese Sprangaltop | Japani Lovgrass | Indian Lovgrass

Goosegrass | Purple Nutsedge | Yellow Nutsedge

Fig. 8.1: Grassy and nut sedges weeds

8.1.3 Broad Leaved Weeds

1. **False daisy** (*Eclipta alba*): Belongs to family Asteraceae locally called as safed phool buti. It is an annual herb grows upto 90 cm. The stem is much-branched, slender, reddish, covered with short, stiff hairs with roots at the lower nodes. Flower head is a cluster of sessile white flowers.

2. **Tropical spiderwort** (*Commelina benghalensis/C. diffusa*): Belongs to family Commelinaceae locally known as climbing dayflower. A creeping herb, mat type growth, stem rooting at the nodes, leaves are sessile (short-petioled in *C. benghalensis*) and flowers are blue in color.

Notes

3. **Goat weed** (*Ageratum conyzoides*): Belongs to family Asteraceae locally known as gandhili. The leaves are opposite or the upper alternate, more or less hairy on both surfaces. Flowers are white, pale blue or violet with a disagreeable odour similar to goat's herd.

4. **Chickenspike** (*Sphenoclea zeylanica*): Belongs to family Sphenocleaceae locally known as mirch booti. It is an erect annual herb. Leaves are simple and spirally arranged, light green, borne on short stalks. Flowers densely crowded, white to greenish and sessile.

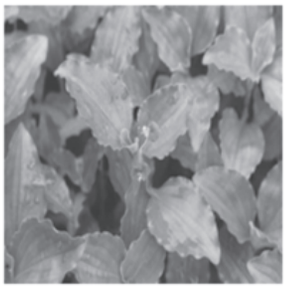
5. **Red Amania or Pink Amania** (*Ammania gracilis*): Belongs to family Lythraceae locally known as Gathjod. It is a straight growing annual weed. Leaves are single and arranged opposite to each other.

6. **European Water Clover** (*Marsilea quadrifolia*): Belongs to family Marsileceae locally known as dhaan papad or char patti. It is a perennial, aquatic fern, having quadrifoliate leaves with long slender petioles arranged in a whorl. Stems are slender with creeping rhizome.

7. **Horse Purslane/ Black pig weed** (*Trianthema portulacastrum*): Belongs to family Aizoaceae locally known as Santhi. It is an annual weed with green to red in color and fleshy. Leaves have small round or oval blades borne on short petioles.

8. **Broadleaf Arrowhead** (*Saggitaria latifolia*): Belongs to family Alismataceae locally known as Duck potato, Indian potato. It is a variably sized (2 to 20 meters in length) stemless, perennial weed growing in colonies that can cover large area of ground. The roots are white and thin, producing white tubers covered with a purplish skin leaves, are spongy and solid having parallel venation meeting in the middle.

False daisy

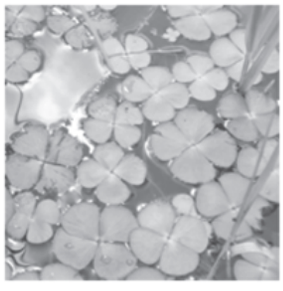


Tropical spiderwort

Goat weed

Chickenspike

Red amania or pink amania



European water clover

Notes

Horse purslane/ Black pig weed

Broadleaf arrowhead

Fig. 8.2: Broad leaved weeds

8.2 INTEGRATED WEED MANAGEMENT

8.2.1 Transplanted Rice

Crop Rotation

Crop rotation is an important component of IWM. The choice and sequencing of crops affects long-term weed population dynamics, and consequently weed management. In traditional farming, rotations comprised of crops with different life cycles were a key component of weed management. Different planting and harvest dates among these crops provide more opportunities to prevent either plant establishment or seed production by weeds. In rice/wheat cropping system, sequences involving summer cowpea for fodder or *Sesbania aculeata* for green manuring, followed by conventional tillage resulted in significantly lowest population of grasses and sedges.

It is suggested that an integrated weed management strategy involving summer ploughing, and inter-crop cultivation is essential for effective weed control in lowland rice in order to ensure higher N-use efficiency and crop productivity.

Flooding

Continuous flooding the field after transplanting controls the weed seed germination.

Chemical method

The weeds in paddy can be controlled chemically by using one of the following chemical given in Table 8.1.

Notes

Table 8.1: List of alternate herbicides used in transplanted rice

Type of weed flora	Herbicides	Dose (g a.i./ha)	Time of application (DAS/ DAT)
Mixed weed flora	Butachlor 50%EC	1500	0-3 DAT
	Thiobencarb EC	3000 (Product dose)	-do-
	Pemndimethalin 30% EC	900	-do-
	Pretilachlor 50% EC	1000	-do-
	Pretilachor 40% EW	1000	
	Anilofos 30% EC	400	-do-
	Anilofos 50% EC	400	
	Anilofos 18% EC	400	
	Oxadiargyl 80%WP	100	-do-
	Fluchloralin 50%EC	600-700	-do-
	Butachlor 5%G	1500	-do-
	Thiobencarb Granule	6000 (Product dose)	-do-
	Fluchloralin Granule	2500-3000 (Product dose)	-do-
	Bispyribac sodium 10% SC	25	15-25 DAT
Broadleaved weeds and sedges	Metsulfuron + chlorimuron 20%WP	4	20-25 DAT
	Ethoxysulfuron 15% WDG	18.8	-do-
	2,4-D Ester/ Amine	380/ 580	-do-

INTEXT QUESTIONS 8.1

1. The dose of Pretilachlor 50%EC is ..... g a.i./ha.
2. Nut sedges are mainly propagated through .....
3. False daisy and Goat weed are belongs to Family .....
4. The scientific name of Barnyard Grass is .....

8.2.2 Direct Seeded Rice (DSR)

Weed flora of the direct seeded fields is quite different than the conventional puddle transplant rice due to difference in moisture status in the soil. The grasses other than *Echinochloa crusgalli* and *E. colonum,* along with sedges like *Cyperus rotundus* may dominate the field of direct seeded rice. For broad spectrum weed control, apply suitable herbicides (as per table 8.2) by knapsack sprayer fitted with flat fan nozzle.

Notes

Stale Seed Bed Technique

Stale seed bed technique (encourage emergence of weeds by applying irrigation & ploughing down) should be adopted for reducing the load of weeds in direct seeded rice. This will also help in tackling the problem of germination of previous season rice seeds and weedy rice, if any.

Chemical Method

(i) In *vattar* DSR, apply pendimethalin 30%EC @ 1.3 *l*/acre just after sowing (JAS) in a spray volume of 200 *l* water. Spray should be done on moist soil. Apply Bispyribac sodium 10%SC (Nominee Gold 10%SC) @ 100 ml/acre at 15-25 days after sowing in a spray volume of 120 *l* water.

(ii) In Dry DSR, immediately after irrigation apply oxadiargyl 80%WP (Topstar 80%WP) @ 50 g/ acre in moist soil after irrigation (0-3 days after sowing) in a spray volume of 120 *l* water. Apply Bispyribac sodium 10%SC (Nominee Gold 10%SC) @ 100 ml/acre at 15-25 days after sowing in a spray volume of 120 litres water.

Table 8.2: List of alternate herbicides used in DSR

Type of Weed flora	Herbicides	Dose (g a.i./ha)	Time of application
Complex weed flora	Pendimethalin 30%EC	1000	0-3 DAS
	Bispyribac-Na 10%SC	25	15-25 DAS
	Bispyribac+ pyrazosulfuron	25+25	-do-
	Pyrazosulfuron 10%WP	25	-do-
Grassy weeds	Fenoxaprop+ safener 6.9%EC	60	-do-
Broadleaf weeds and sedges	Ethoxysulfuron 15%WDG	18.8	-do-
	Metsulfuron+chlorimuron 20%WP	4	-do-
	2.4-D 38%EC/ 58%SL	400/600	-do-

INTEXT QUESTIONS 8.2

1. In Vattar DSR the herbicide used within 3 days is .....
2. The herbicide Bispyribac sodium 10% Sl is applied at ..... DAS at the rate of ..... ml/ha.
3. The nozzle used in herbicide spray is .....

WHAT YOU HAVE LEARNT

Notes

Let us recapitulate and enlist salient points we have learnt through this lesson:

- Three types of weed observed in paddy field i.e Grassy, Nut sedges and Broad leaved weeds**.**
- Integrated weed management strategy involving summer ploughing and inter-crop cultivation is essential for effective weed control in lowland rice.
- In rice-wheat cropping system, sequences involving summer cowpea for fodder or Sesbania for green manuring, resulted in significantly lowest population of grasses and sedges.
- At 15-25 days after sowing, apply bispyribac sodium 10%SC (Nominee Gold 10%SC) @ 100 ml/ acre in a spray volume of 120 liter water in both transplanted paddy as well as in DSR.
- Pre emergence application of butachlor 50 EC @ 3.0 *l*/ha or anilophos 50EC @ 1.0 *l*/ha or oxadiargyl 70-100 g/ha effectively control control grasses and broad leaved weed in lowland paddy.

TERMINAL EXERCISE

1. Describe the methods of weed control in direct seeded rice (DSR).
2. Explain the chemical weed control method in transplanted rice.
3. Write down the names (5 each) of the grassy and broad leaves weeds of paddy field along with their scientific name.
4. Explain the method of stale seed bed techniques for weed control in DSR.
5. What is IWA? Write down its components.

ANSWERS TO INTEXT QUESTIONS

8.1

1. 1000
2. rhizomes
3. asteraceae
4. e*chinochloa crusgalli*

8.2

1. pendimethalin
2. 15-25; 100
3. flat fan

Notes

9

INTEGRATED PEST MANAGEMENT

Insects are everywhere. They are, by far, the most common animals on our planet. Those insects that are harmful to living beings are called pests. Insect pests cause enormous damage to the crop causing severe economic losses. To control these insect pests, use of synthetic insecticides & pesticides has increased rapidly. Though these chemicals are said to have contributed significantly to the food security by the way of increased crop production & reduced post harvest losses, there is a growing concern over the ill-effect of these chemicals on human & animal health, environment, natural resources and sustainability of agriculture production. To minimize the indiscriminate and judicious use of these chemicals, Integrated Pest Management (IPM) has been formulated as principle of plant protection in over all crop protection programmes under the National Agriculture policy of the Govt. of India.

Integrated Pest Management (IPM) is that method of pest control, which utilizes all suitable techniques of pest control to reduce pest populations and maintain them below economic injury level. IPM also refers to combination of all feasible methods of pest control in a judiciously manner to bring down the pest population. The IPM should be economically viable and ecologically sound. Tools of IPM includes, Monitoring of the pests and their potential damage, Pest resistant varieties, cultural pest control, mechanical control, biological control and chemical control.

The paddy crop is prone to many insect pests throughout the growth period. Hence, adoption of IPM technologies is the best to tackle the pest problem. Paddy IPM provides a framework for integrating knowledge, skills and information on paddy pest management.

OBJECTIVES

After reading this lesson, you will be able to:

- identify the major insect-pests of paddy;
- explain the life cycle of major paddy insect-pests;

Notes

- identify the symptoms of different insect-pests damage;
- explain cultural, biological and chemical management of paddy insect-pests;
- implement Integrated Pest Management in paddy.

9.1 MAJOR INSECT-PESTS OF PADDY

At present about twenty insect pests cause damage to different parts or entire paddy plant resulting in an estimated yield loss of 20 to 30%. The major insect-pests are described below:

9.1.1 Stem Borers

Stem borers are one of the most destructive pests of paddy in India. Following three major lepidopterous species of stem borers attack on paddy crop:

Yellow stem borer - *Scirpophaga incertules* (Walker)

White stem borer - *Scirpophaga innotata* (Walker)

Pink stem borer - *Sesamia inferens* (Walker)

Identification

The caterpillars alone are destructive. When full- grown, they measure about 20 mm and are dirty white or greenish yellow, having brown head and pronotum. The adults have a wing expanse of 25-45 mm and are yellowish white with orange yellow front wings. The female moth is bigger than the male and has a black spot in the centre on each of the forewings. The females have a prominent tuft of brownish yellow silken hair at the tip of their abdomen.

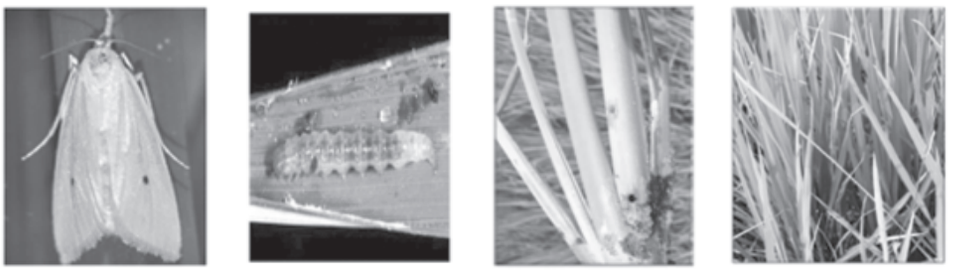
Life Cycle

A single female moth lays about 120-150 eggs in masses and each egg mass contains 50-80 eggs. The eggs are covered with yellow brown hairs of the female tuft. The eggs hatch in 6-7 days. The fully grown larva is pale yellow in colour with orange head. The larva grown in 6 stages in 16-27 days. Pupation takes place inside the attacked plant and takes 9-12 days. The life cycle is completed in 31-40 days. There are 4-5 generations per year.

Nature of Damage

Most of the paddy varieties are susceptible to this pest and sometimes suffer heavy damages. The damage is caused by caterpillars. When the plants are attacked at vegetative stage, the central leaf whorl does not unfold due to larval feeding and turns brownish and dries off, the damage is known as 'dead hearts' whereas the plants when attacked after panicle initiation, produce ears devoid of grains it is known as the 'white ears'.

Notes



A B C D

Fig. 9.1: Stem borer: (A) Adult (B) Caterpillar (C) Damage (D) Infected field

Economic Threshold Level (ETL)

Planting to pre-tillering: 5% dead hearts or 1 egg mass/$m^{2.}$

Mid tillering stage: 5% dead heart.

Panicle initiation to booting: 1 moth/m^2.

Flowering and after: 1 moth/m^2.

Management Practices

- Harvesting at ground level removes larvae in the stubbles. Ploughing the field immediately after harvest kills larvae and pupae in the stubble.
- Summer ploughing and stubble management to be taken up.
- Grow resistant/tolerant varieties like Ratna, Deepti, Saket 4, Payur, TKM 6.
- Apply neem cake @ 150 kg/ha in main field before transplanting.
- Install light trap in the field.
- Use recommended rates of nitrogenous fertilizer in split applications.
- Installation of pheromone traps to monitor the pest activity is helpful.
- Release of *Trichogramma japonicum* @ 1,00,000-1,50,000/ ha after 30 days of transplanting and 2-6 subsequent release, depending upon the intensity of infestation, are helpful for controlling *S. incertulas.*
- Granular insecticides like Cartap hydrochloride 4G, Fipronil 0.3 GR @ 25 kg/ ha are effective against stem borer. Amongst the sprayable insecticides, cartap hydrochloride 50 SP or Fipronil 5 SC @ 0.02 % or Triazophos 40 EC @ 0.03% give effective control of the stem borers when applied at ETL.

9.1.2 Paddy Leaf Folder {*Cnaphalocrosis medinalis* (Guenee)}

Identification

The caterpillars are greenish, very agile and feed inside the fold made by fastening together the edges of a leaf. The moths are golden or yellowish brown and measure 8-10

Notes

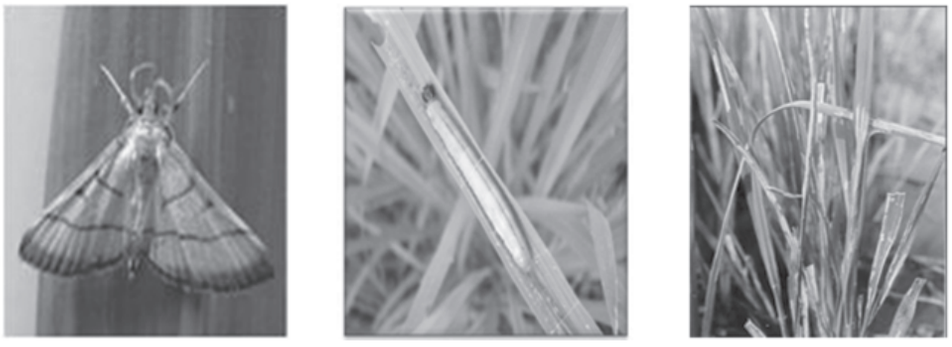
mm in length. The wings have 2-3 wavy lines characterized by dark bands. In case of heavy infestation, the plants appear whitish and scorched.

Life cycle

A single female moth lays about 300 eggs. The egg laying period varies from 3-4 days. The newly hatched larva is greenish white in colour. The larva remains inside the folds and scratch green tissues, resulting in white membranous folded leaves. The larval period lasts 15-25 days. The fully grown larva is greenish – yellow in colour. The pupal period lasts 6-8 days. Adults survive for 3-4 days and total life cycle takes 24-29 days.

Nature of Damage

The adults lay eggs during night hours on the leaves. The young larvae sew the leaf margins from the top and form cone like structures. They remain within the leaf fold and come out during feeding. The larvae feed on chlorophyll. As a result of feeding white, longitudinal, parallel lines develop on the leaves, which subsequently dry out. More damage is caused to boot leaf and the yield is reduced drastically.



A B C

Fig. 9.2: Leaf Folder: (A) Adult (B) Larvae (C) Infected field

Economic Threshhold Level (ETL)

Planting to pre- tillering: One damaged leaf/hill

Mid tillering stages: 1-2 freshly damaged leaves/hill

Panicle initiation to booting: 1-2 damaged leaves/hill

Management Practices

- Use resistant/tolerant varieties like Mahanadi, Gajapati, Prachi, Urbasi, Ramachandi, Kanchan, Mahanadi, TKM 1, TKM 2, and TKM 6.
- Installation of light trap in the field.
- Release of parasitoid *T.japonicum* @ 1-1.5 lakhs/ha 2-3 times at 7 days interval.
- Proper sanitation of the field before transplanting of the paddy crop.

Notes

- *Beauveria bassiana, Nomuraea rileyi* and *Zoopthora radicans* are effective bio-agents to minimize the population of leaf folder complex.
- Spraying of Cartap hydrochloride 50 SP @ 500g, Quinalphos 125@ 500 ml, Ethofenprox 500 ml, or Cypermethrin (10FC) @ 5 g/ha at boot leaf stage of the crop.

9.1.3 Brown Plant Hopper {*Nilaparvata lugens* (Stal)}

Identification

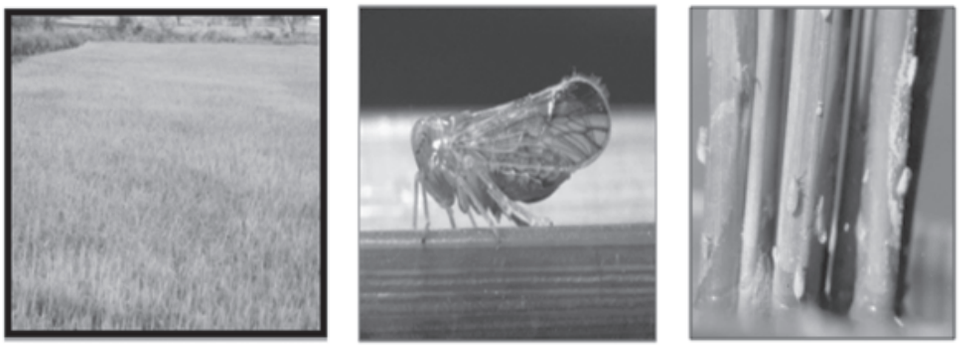
The adults are brown in colour with brown eyes and measure 3.5-4.5 mm in length. Their legs are light brown and the tarsal claws are black. Wings are hyaline with brown markings and dark veins. The nymphs are brownish- black in colour and have grayish-blue eyes.

Life cycle

The female starts laying eggs within 3-10 days of its emergence and deposit eggs in masses by lacerating the parenchymal tissue. The number of eggs per mass varies from 2-11 and a female lays on an average, 124 egg masses. Eggs are somewhat dark and cylindrical, having two distinct spots. Incubation period ranges between 4-8 days. Nymphs on emergence, start feeding on young leaves and after moulting 5 times, they become adult in 2-3 weeks. The total life cycle takes about 18-25 days.

Nature of Damage

Both the adults and nymphs remain at the plant base and feed from that position. Females by way of egg laying cause injury to the leaf sheath. Both nymphs and adults suck the plant sap from the leaf sheath at the base of the plants. Due to heavy desapping the plants turn yellow and then finally die. This condition is known as 'hopper burn'. Nymphs also transmit 'grassy stunt viral' disease. They are also the vector of grassy stunt virus in paddy crop.



(A) Hopper Burn (B) Brown Plant Hopper Adult

Fig. 9.3

Notes

Economic Threshhold Level (ETL)

Planting to pre tillering: 5-10 insects / hill

Mid tillering: 5-10 insects / hill

Panicle initation to booting; 5-10 insects / hill

Flowering and after: 5-10 insects / hill

Management Practices

- Closer spacing of 15 × 10 cm^2 creates favourable microclimate in field for rapid development of hopper population. Hence, a spacing of 20x 15cm2 should be followed.
- Resistant varieties like Chaitanya, Chandana, Deepti, Bhoi, Kanchan, Prachi, Ananga, Surendra, etc may be taken up for cultivation.
- Alternate drying and wetting the field during peak infestation and draining out the standing water from the field 2-3 times checks the population of the hopper to a large extent.
- Alley 30 cm wide after every 3 m of paddy planting provides proper aeration to the crop, which ultimately restricts the multiplication of the pest. Making of alleys also help in insecticidal spraying as applicator can move freely in the field.
- Spraying of Dichlorovos 30 EC or Dimethoate 30 EC @ 0.05 % or Imidacloprid 17.8 SL @ 0.005% at ETL of 5-10 insects/ hill. In severe infestation spray of Ethofenprox 10 EC or Buprofezin 25 SC @ 0.02% application should be repeated if hopper population persists above ETL beyond a week after application. The spraying nozzle should be directed at the basal portion of the plants.

9.1.4 Paddy Hispa {*Dicladispa armigera* (Olivier)}

Identification

The adult is small bluish black beetle measuring 5mm in length and is recognized by numerous short spines on the body, which gives it a characteristic appearance. The legless, creamy white larvae are not easily seen, because they are concealed inside the leaf tissues.

Life cycle

Each female the leaves lays on an average 55 eggs which hatch within 3-5 days. The grub feeds inside for 15 days on an average. Pupal period lasts for 3-5 days. The adult survives for an averages period of 14 and 20 days in case of male and female, respectively.

Nature of Damage

Damage is caused both by grubs and adults, which feed on the leaves. The grub mines into the leaf tissue between the upper and lower epidermis and produces long irregular white patches. Adult beetles feed on the green portion of the leaf by scarping out the matter from

Notes

the outer surface and leaving behind only the epidermal membrane. The pest prefers young plants and so the attack commences in the nursery itself.

(A) Paddy Hispa Adult

(B) Damage of Paddy Hispa

Fig. 9.4:

Economic Threshhold Level (ETL)

Planting to pre- tillering: one adult or one damaged leaf/ hill.

Mid tillering: One adult or 1-2 damaged leaves/ hill.

Management practices

- Removal of grassy weeds in and around paddy field, removal of alternate hosts.
- Hand picking of damaged leaves, removal of grubs from the fields.
- Damaged leaves should be pulled through the leaf canopy.
- In the main fields, spraying of Quinalphos or Trizophos (40EC) @ 0.05 % should be done.

9.1.5 Case Worm {*Nymphula depunctalis*}

Identification

The adult is a small white moth with yellow and dark specks on the fore and hind wings. Margins of the wings are dark in colour. Caterpillars are pale green with orange head.

Life Cycle

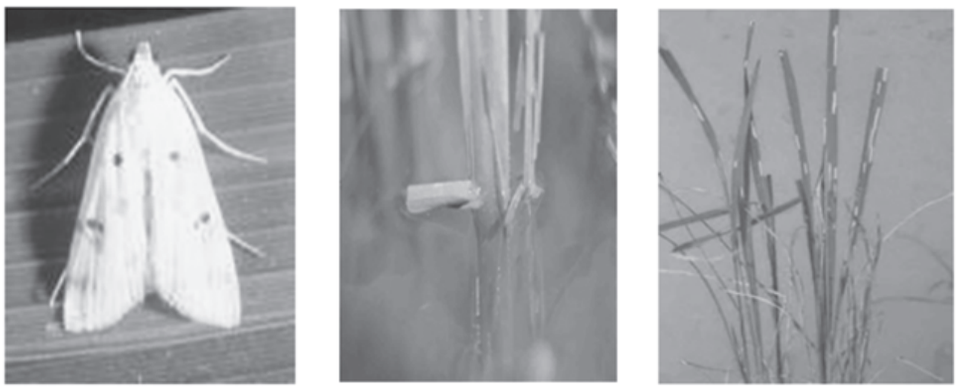
Female lays 50 eggs single on the leaves of paddy and grasses which hatch in 4-6 days and becomes larva that takes 20-25 days to become pupa inside the leaf case and remains attached to base of the tillers. The adult emerges from pupa in 6-8 days. Life cycle occupies 19-37 days.

Nature of Damage

Damage is caused by the caterpillars which feed on the leaves tips causing cut ends. The larvae scrap leaf tissue, leaving behind only the papery upper epidermis. Characteristic leaf damage has horizontal rows of green material giving ladder like appearance. The

Notes

larvae wrap themselves in the cut tips of leaves and these 'case' are seen on the sides of leaves or floating in water. Larvae lead a semi aquatic life floating in their tubular cases on the surface of the water or attached to the stems at or above the water level, when about to swim or feed they protrude their head.



A B C

Fig. 9.5: Case Worm: (A) Adult (B) Infestation (C) Infected Plant

Economic Threshhold Level (ETL)

Mid- tillering: 1-2 cases/ hill

Management Practices

- Drain off water from the field to kill the floating larvae
- Put some kerosene in the field water and dislodge the leaf cases by shaking the plants by passing ropes or by branches of thorny plants
- Spray methyl parathion 50 EC @ 0.05%.

9.1.6 Paddy 'Gundhi' Bug {*Leptocorisa varicornis*}

Identification

The adults are slender, about 20 mm long and greenish brown. They have long legs and antennae with four joints. The newly hatched nymphs are about 2 mm long and are pale green. However as it grows, the green colour deepens. The grown up nymhs are very similar to the adults in colour and size, but they are wingless.

Life cycle

The bug breeds all the year round on grasses and various other green plants and appears in paddy field generally in August and is most active from the middle of that month to November. Female lays 200-300 round yellow eggs in rows on the leaves. Eggs hatch in about 6-7 days and the nymphs grow to maturity in 5 stages within 25-30 days. Adult bugs live for 33-35 days.

Notes

Nature of Damage

Damage is caused both by nymphs and adults by sucking sap. Paddy fields severely attacked by this pest emit a repugnant smell, which gives this pest the name 'gundhi bug'. Although they feed on all parts of the plants, they prefer the grains at the milky stage. The nymphs and the adults suck juice from the developing grains in the milky stage causing incompletely filled panicles or panicles with empty grains. Black or brown spots appear around the holes made by the bugs on which a sooty mould may develop.

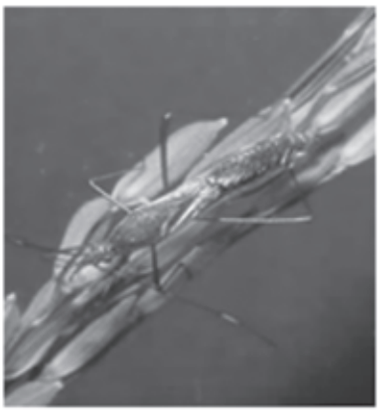


Fig. 9.6: Gundhi bug adult

Economic Threshhold Level (ETL)

Flowering and after: One bug/ hill

Management Practices

- Paddy fields and the surrounding bunds should be kept clean of grass and weeds to deny the hibernating insects their alternate food.
- Growing of resistant varieties like Surekha, Vikram, Triveni, Samalei, Phalguna, Lalat,Pratap, Gouri, Ptb 21, Siam 29, Eswarakora, etc is beneficial.
- Egg bearing leaves should be clipped and burnt.
- The adults could be captured in light traps and destroyed.
- The tiger beetle, *Cicindela sexpunctata* predates upon this bug.
- Application of granular insecticides like Carbofuran 3Gor Phorate 10G @ 1 kg a.i./ ha at transplanting and Cartap hydrochloride 4G @ 0.3 kg a.i./ha at 3 weeks after transplanting can be taken up.
- Dust methyl parathion 2% or Malathion 5% @ 25kg/ ha.

Notes

9.1.7 Paddy Root Weevil {*Echinocnemus oryzae* (Marshall)}

Identification

Damage is caused by grubs, which feed on rootlets of paddy plants. They are translucent white and measure about 6 mm in length. There are six pairs of prominent tubercles on the dorsal side of the abdomen. Adult weevils are black or piteous (pitch black), about 4 x 2 mm2 in size with dense clothing of scales and long rostrum**.**

Life cycle

This pest is active only from July to September and passes the rest of the period as pupa in the soil at depths of 8-20cm. Weevils emerge in July with the first shower of rain and are seen sitting in large numbers on paddy plants at this time. Eggs that are laid on the plant hatch in a few days. The grubs lead an aquatic life and feed on the root hairs. Tubercles on the abdomen help them in respiration and they obtain oxygen from air-spaces inside the roots of the host plants. Grubs are full- grown by the middle of September when they bury themselves deep into the soil for pupation. The adult emerge next year in July and thus the pest completes only one generation in a year.

Nature of Damage

Damage is caused by the grubs by feeding on fibrous roots. The infested plants become weak, stunted and pale yellow and ultimately dry or tillering is reduced. Adults feed on newly transplanted paddy, but seldom cause economic damage. In severe case of incidence the plants wither and the fields show many patches that have to be filled by transplanting of fresh seedlings.

Fig. 9.7: Root weevil adult

Management Practices

- Clean culture to remove alternate food.
- Removal and destruction of stubbles to ensure reduction of hibernating stages.
- Application of Cartap hydrochloride 4G, Phorate 10 G or Fipronil 0.3 GR granules @ 25 kg / ha in standing water.

Notes

INTEXT QUESTIONS 9.1

State True / False

1. Dead heart is a damage caused by stem borer.
2. When paddy leaf folder infestation is high, the plant may have many folded leaves.
3. ETL of stem borer at PI to booting stage is 5 moth / m^2.
4. Pupa is the harmful stage of paddy hispa.
5. Gundhi bug prefers the paddy grains at the milk stage.

9.2 TOOLS OF INTEGRATED PEST MANAGEMENT IN PADDY

Major tools used in integrated pest management in paddy includes

1. Cultural
2. Mechanical
3. Biological
4. Chemical

9.2.1 Cultural Practices

- Judicious use of nitrogen fertilizers is very important for effective pest control. Apply of optimum dose of nitrogen (based on soil testing) in 2 – 3 splits.
- Raise *Sesbania* or sunhemp and incorporate 40 - 45 days old crop in soil during land preparation, wherever possible.
- Select suitable resistant or moderately resistant variety.
- Use disease and insect free pure seed.
- In termites endemic areas, seed treatment with Chlorpyriphos 20 EC @ 4.5ml/kg seed along with 10% solution of gum Arabica or Imidacloprid 200 SL @ 0.25 litre/ 100 kg seed along with 10% solution of gum Arabica in 3.75 litre of water just before sowin is recommended.
- Timely planting/sowing. Early planting in gall midge endemic areas for avoiding the gall midge incidence.
- Raising of healthy nursery.
- As far as possible paddy seedling should be free from weed seedlings at the time of transplanting.
- Destruction of left over nursery, removal of weeds from field and cleaning of bunds for minimizing the pest build up.
- Normal spacing with 30-36 hills/ m^2 depending on the duration of the variety.

Notes

- 30 cm alley formations at every 2.5 to 3 m distance in plant hopper and sheath blight endemic areas.
- Proper water management (alternate wetting and drying to avoid water stagnation) in plant hopper, bacterial blight and stem rot endemic areas.
- Harvest close to ground level to destroy insect pest present in the internodes/stubbles. This will also expose the insects to birds thus helping in natural biocontrol of insect pests.
- After harvest, the fields should be thoroughly flooded with water and ploughed with discs or rotavators to kill hibernating larvae of stem borer present in the stubbles. Summer ploughing of fields also expose larvae and pupae of paddy swarming or ear cutting caterpillar (climbing cutworm) hidden in the soil to birds and weather factors.

9.2.2 Mechanical Practices

- Collection of egg masses of borers and putting them in a bamboo cage-cum-percher till flowering, which will permit the escape of egg parasites, trap and kill the hatching larvae. Besides, these would allow perching of predatory birds, removal and destruction (burn) of diseased/pest infested plant parts.
- Clipping of paddy seedlings tips at the time of transplanting to minimize carryover of paddy hispa, case worm and stem borer infestation from seed bed to the transplanted fields.
- Use of coir rope in paddy crop for dislodging case worm, cut worm and swarming caterpillar and leaf folder larvae etc on to kerosinized water (1*l* of kerosene mixed on 25 kg soil for broadcast in 1 ha).
- Installation of insect sex pheromone traps @ 20 per hectare on a spacing of 20 × 20 m^2 is very effective for management of stem borers.

9.2.3 Biological Control Practices

- *Trichogramma japonicum* and *T chilonis* may be released @ 1 lakh/ha on appearance of egg masses / moth of yellow stem borer and leaf folder in the field.
- Natural enemies such as spiders, drynids, water bugs, mirid bugs, damsel flies, dragonflies, meadow grasshoppers, staphylinid beetles, carabids, coccinellids, *Apanteles, Tetrastichus, Telenomus, Trichogramma, Bracon, Platygaster* etc. should be conserved.
- Protection of natural habitats within the farm boundary may help in conserving natural enemies of pests.
- Management of farmland and paddy bunds with planting of flowering weeds like marigold, sun hemp increases beneficial natural enemy population and also reduce the incidence of root knot nematodes.
- Provide refuge like straw bundles having charged with spiders to help in build up spider population and to provide perch for birds.

Notes

9.2.4 Chemical Control Practices

- Spraying should be undertaken based on the ETL values.
- Insecticides like Monocrotophos/ Ethofenprox/ Profenophos/ Triazophos/ Fipronil/ Imidacloprid/ Chlorpyriphos/ Quinalphos/ Phosalone etc. can be sprayed on need basis.
- Remember that for Brown Plant Hopper (BPH) control, never spray resurgence causing insecticides like Chlorpyriphos/ Methyl parathion/ Quinalphos etc.
- Alternate wetting and drying of the field followed by alley making are the first approach which should be followed by basal part spraying of BPMC/ Ethofenoprox/ Fipronil/ Monocrotophos, etc.
- For gundhi bug control, dusting of insecticide is very good. Continuous spraying of Neem Seed Karnel Extraction (NSKE)@ 5% at an interval of 7 days may be done.
- For migratory insects like swarming caterpillar and ear cutting caterpillar, evening spraying of chlorpyriphos is effective.
- Application of dust formulation of insecticides is also effective in checking the infestation.

INTEXT QUESTIONS 9.2

State True / False

1 It is safer to provide the plants with excessive nitrogenious fertilizer.

2 Clipping of paddy seedling tips is not effective for carryover of hispa and stem borer from nursery to main field.

3 All insects are harmful for paddy farming.

4 Use of 20 pheromone traps/ ha is effective for control of stem borer.

WHAT YOU HAVE LEARNT

Let us recapitulate and enlist salient points we have learnt through this lesson:

- About 20-30% of paddy is lost by insect-pests.
- The most common insects observed on the paddy plant are stem borer, leaf folder, brown plant hopper, paddy hispa, case worm, gundhi bug and root weevil.
- The IPM follows a system approach that combines a wide array of crop production and protection practices to reduce the economic losses caused by the pests.
- IPM tools viz. cultural, mechanical, biological and need based use of chemicals are effective for management of paddy insects.

TERMINAL EXERCISE

1. Name any three major insects of paddy with their identification features and diagram.
2. Explain the control of brown plant hopper and stem borer through natural, biological and chemical method.
3. Define IPM. Explain the tools of IPM.
4. Describe the management of paddy insects through cultural practices.
5. Describe the management of paddy insects mechanically.
6. How paddy insects may be controlled by biological practices?
7. What are the chemical control measures adopted to control paddy insects? Why chemicals are the last choice for controlling them?

ANSWERS TO INTEXT QUESTIONS

9.1

1. True
2. True
3. False
4. False
5. True

9.2

1. False
2. False
3. False
4. True

Notes

Notes

10

INTEGRATED DISEASE MANAGEMENT

In the previous lesson we have learnt about the insect pest causing damage to the paddy crop. However, diseases caused by fungus, bacteria, virus and nematodes are the most significant constraints responsible for low yield of this crop in India. The annual losses due to rice diseases are estimated to be 10-15 per cent on an average basis worldwide. Rice diseases have always had a significant impact on rice supply. Historically, severe epidemics led to serious food shortages. The Bengal famine in 1942 was, in part, attributed to brown spot disease. Thus, minimizing the occurrence of diseases and reducing losses are central to sustaining rice productivity.

Paddy diseases are classified into four groups viz., fungal, bacterial, viral and nematode, according to their causal agents. The distribution of paddy diseases in temperate and tropical regions is affected by weather factors mainly temperature and relative humidity. The per cent incidence of diseases depends upon host- varietal response and cultural practices.

You may observe the symptoms of diseases on leaves, stem, leaf sheaths, inflorescence and grains. The fungal diseases and one bacterial disease are usually exhibited by localized spots on the leaves, sheaths and stems. Major bacterial diseases are systemic, causing either wilting of young plants or lesions on the margin of leaves. Viral diseases, being systemic are generally characterised by abnormal growth and change of leaf colour to white, yellow or orange.

Integrated Disease Management (IDM) is a holistic approach, in which all possible methods (cultural, biological and chemical) are unified in way to control the disease(s) with least harmful effect on environment and to minimize the ill effect of chemicals. The IDM follows a system approach that combines all practices with a special emphasis on health and environment, use of biotic agents, to minimize the indiscriminate and injudicious use of chemical. It reduces the economic losses caused by the diseases.

OBJECTIVES

Notes

After reading this lesson you will be able to:

- identify the major fungal, bacterial and viral diseases of paddy;
- explain the favourable condition and mode of spread and survival of diseases;
- manage the diseases through cultural, biological and chemical methods.

10.1 FUNGAL DISEASE OF PADDY

The important fungal diseases of paddy are blast, sheath blight, sheath rot, leaf scald, bakanae, brown leaf spot, narrow brown leaf spot and stem rot.

10.1.1 Blast

(*Pyricularia oryzae) (Syn: P. grisea)(Sexual stage: Magnaporthe grisea)*

Symptoms

The fungus attacks on the crop at all stages from seedlings in nursery to heading in main field. The typical symptoms appear on leaves, leaf sheath, rachis, nodes and even on the glumes. On the leaves, the lesions start as small water soaked bluish green flecks, soon enlarge and form characteristic spindle shaped spots with grey centre and dark brown margin **(Leaf blast).** The lesions join together as the disease progresses and large areas of the leaves dry up and wither. Similar spots are also formed on the sheath. Severely infected nursery and field show a burnt appearance.

In infected nodes, irregular black areas encircle the nodes can be noticed. The affected nodes may break up and all the plant parts above the infected nodes may die **(Nodal blast).** At the flower emergence, fungus attacks on the peduncle which is engirdled, and the lesion turns to brownish-black. This stage of infection is commonly referred to as rotten neck/neck rot/neck blast/panicle blast. In early neck infection, grain filling does not occur and the panicle remains erect like a dead heart caused by a stem borer. In the late infection, partial grain filling occurs. Small brown to black spots also may be observed on glumes of the heavily infected panicles. The yield losses caused by pathogen ranged from 30-61 per cent depending upon the stages of infection.

Healthy leaf

Infected leaf

Blast spot

Notes

Collar Nodal Neck

Fig. 10.1: Symptoms of blast damage

Favourable Conditions

- Application of excess doses of nitrogenous fertilizers.
- Intermittent drizzles, cloudy weather, high relative humidity (93-99%), low night temperature (between 15-200°C or less than 26°C), more number of rainy days, longer duration of dew, slow wind movement.
- Availability of collateral hosts.

Mode of Spread and Survival

The disease spreads primarily through airborne conidia since spores of the fungus present throughout the year. Mycelium and conidia in the infected straw and seeds are important sources of inoculum. Irrigation water may carry the conidia to different fields. The fungus also survives on collateral hosts *viz., Panicum repens, Digitaria magrginata, Brachiaria mutica, Leersia hexandra, Dinebra retroflea, Echinochloa crusgalli* and *Stenotaphrum secondatum.*

Forecasting

Forecasting of paddy blast can be made on the basis of minimum night temperature range of 20-26°C in association with a high relative humidity range of 90% and above lasting for a period of a week or more during any of the three susceptible phases of crop growth, viz., seedling stage, post transplanting tillering stage and neck emergence stage. In Japan, the first leaf blast model was developed and named as BLAST. Later based on different field experiments various models were developed namely, PYRICULARIA, PYRIVIEW, BLASTAM, EPIBLA and P BLAST.

Disease Management

➲ **Cultural control**

- Remove collateral weed hosts from bunds and channels.

Notes

- Use only disease free seedlings.
- Apply recommended doses of fertilizers.
- Apply N in three split doses (50% basal, 25% in tillering phase and 25% N in panicle initiation stage).
- The varieties viz. Vikas, Jaya, IR62, IR64 also showed moderate resistance to blast.
- Avoid close spacing of seedlings in the main field.

➲ **Biological control**

- Seed treatment with bio-control agent *Trichoderma viride* @ 10g/kg or *Pseudomonas fluorescens* @ 10g/kg of seed before sowing.
- Seedling root dipping with *Trichoderma viride* or *Pseudomonas fluorescens* @ 10g/*l* of water for 20 min before transplanting.
- Apply *Trichoderma viride* or *Pseudomonas fluoresces* @ 2.5kg/ha with 150 kg FYM in soil.
- Foliar spray with *Trichoderma viride* or *Pseudomonas fluoresces* liquid formulation @ 5ml/*l*.

➲ **Chemical control**

- Treat the seeds with Carbendazim (50 WP) or Carboxin (37.5 WP) @ 2 g/kg seed or tricyclazol 75 WP @ 2 g/ kg seed.
- Seedling treatment with Carbendazim (50 WP) @2g/*l* of water.
- Spray the following with 500-600 litres of water after observing initial infection of the disease:

  (a) Carbendazim 50WP @ 500g/ha (or) Tricyclozole 75 WP @ 500g/ha (or)

  (b) Metominostrobin 20 SC @ 500ml/ha (or) Azoxystrobin 25 SC @ 500 ml/ha.

Nursery stage: On light infection - Spray Carbendazim 50 WP) @ 2g/*l* water

Pre-Tillering to Mid-Tillering- At 2 to 5 % disease severities - Apply chemical or bio agent liquid formulation spray. Delay top dressing of N fertilizers when infection is seen. At panicle initiation to booting stage, if 2 to 5% leaf area is damaged, apply spray.

Flowering and after –At 5 % leaf area damage or 1 to 2 % neck infection spray of chemicals and bio-agents should be done as prescribed above.

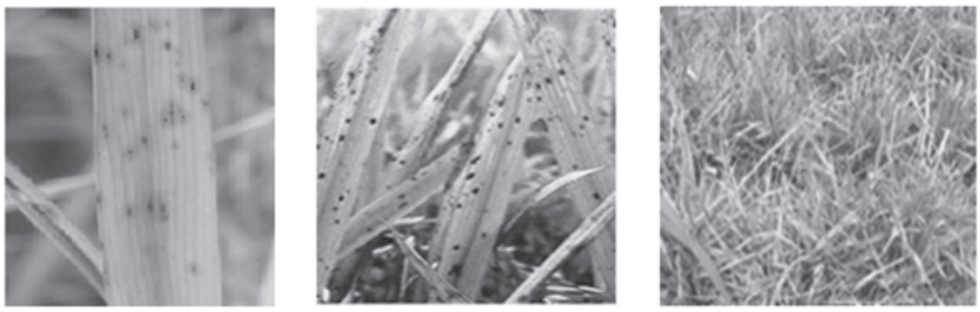
Notes

10.1.2 Brown Spot or Sesame Leaf Spot

(*Helminthosporium oryzae* (Syn : *Bipolaris* oryzae)) (Sexual stage : *Cochliobolus miyabeanus)*

Symptoms

Fungus attacks the crop from seedling in nursery to milk stage in the main field. Symptoms appear as lesions (spots) on the coleoptile, leaf blade, leaf sheath, and glume, being most prominent on the leaf blade and glumes. The disease appears first as minute brown dots, later becoming cylindrical or oval to circular. The several spots coalesce and the leaf dries up. The affected seedlings can be often recognised from a distance by their brownish scorched appearance. Dark brown or black spots also appear on glumes which contain large number of conidiophores and conidia of the fungus. It causes failure of seed germination, seedling mortality and reduces the grain quality and weight. It is called as sesame leaf spot or fungal blight and mostly observed in Bihar, West Bengal, Orissa, A.P and Tamil Nadu.



Infected leaves Advance stage of infection

Fig. 10.2: Symptoms of Brown leaf spot disease

Favourable Conditions

- Temperature of 25-30°C with relative humidity above 80% are highly favourable.
- Excess of nitrogen aggravates the disease incidence.

Mode of Spread and Survival

Infected seeds are the most common source of primary infection. The conidia present on infected grain and mycelium in the infected tissue may viable for 2 to 3 years. The fungus may survive in the soil for 28 months at 30°C and 5 months at 35°C. Air borne conidia infect the plants both in nursery and in main field. Maximum flight of conidia takes place at a wind velocity of 4.0 - 8.8 km per hr. Minimum temperature of 27 -28°C, relative humidity 90-99% and rainfall of 0.4 -14.4 mm favoured the dispersal of the conidia to maximum extent. The fungus also survives on collateral hosts like *Leersia hexandra, Arundo donux,* and *Echinochlo colonum.*

Notes

Disease Management

➲ **Cultural control**

- Field sanitation-removal of collateral hosts and infected debris in the field.
- Use only disease free seeds and seedlings.
- Apply recommended doses of fertilizers and use of slow release nitrogenous fertilizers is advisable.
- Apply N in three split doses (50% basal, 25% in tillering stage and 25% N in panicle initiation stage).
- Avoid close spacing of seedlings in the main field.

➲ **Biological control**

- Seed treatment with bio-control agent *Trichoderma viride* @ 5-10 g/kg or *Pseudomonas fluorescens* @ 10g/kg of seed before sowing.
- Seedling root dipping with *Trichoderma viride* or *Pseudomonas fluorescens* @ 10ml/litre of water for 20 min before transplanting.

➲ **Chemical control**

- Treat the seeds with Carbendazim (50 WP) or Carboxin @ 2 g/kg seed.
- Spray following chemicals after observing initial infection of the disease:

  (a) Nursery treatment with Carbendazim (50 WP) + Mancozeb @ 2.0 g /litre water.

  (b) Spray propiconazole (25 EC) @ 500 ml/ha Metominostrobin (20 SC) @ 500ml/ha on crop with 500 litre water.

  (c) Trifloxystrobin 25% + Tebuconazole 50% (75WG) (@ 0.1%) fungicide was found significantly effective against brown leaf spot disease.

10.1.3 Sheath Rot

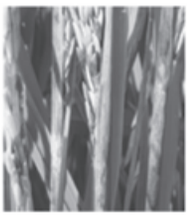
(*Sarocladium oryzae* (Syn : *Acrocylindrium oryzae))*

Symptoms

Initial symptoms are noticed only on the upper most leaf sheath enclosing young panicles. The flag leaf sheath show oblong or irregular greyish brown spots. They enlarge and develop grey centre and brown margins covering major portions of the leaf sheath. The young panicles may remain within the sheath or emerge partially. The panicles rot and abundant whitish powdery fungal growth is formed inside the leaf sheath.

Irregular Spot on sheath

Discolouration of sheath



Panicle remain within sheath

Rottening of flag leaf sheath

Fig. 10.3: Symptoms of sheath rot damage

Favourable Conditions

- Dense planting, high doses of nitrogen, high humidity and temperature around 25-30°C.
- Injuries made by leaf folder, brown plant hopper and mites increase infection. Under most favourable condition, yield reduced up to 40%.

Mode of Spread and Survival

The disease mainly spread through air-borne conidia and also seed-borne.

Disease Management

➲ **Cultural control**

- Apply recommended doses of fertilizers.
- Adopt optimum recommeneded spacing.
- Under high humidity and temperature condition, drain out water and keep dry or moist condition.
- Apply Gypsum @ 500 kg/ha in two equal splits once basally and another at active tillering stage.
- Apply Potassium fertilizer at tillering stage.

➲ **Biological control**

- Seed treatment with bio-control agent *Trichoderma viride* @ 5-10g/kg or *Pseudomonas fluorescens* @ 10g/kg of seed.
- Foliar spray with *Trichoderma viride* or *Pseudomonas fluoresces* liquid formulation @ 5ml per litre of water.

➲ **Chemical control**

- Two spray of Carbendazim (50 WP) 500g or mancozeb (45 WP) @ 1000g or Chlorothalonil 1000 g/ha with 500 litre water at boot leaf stage and 15 days after Ist spray.
- Two spray of Hexaconazole (75 WG) @ 2ml/*l* water. First spray at the time of disease appearance and second spray 15 days later.

10.1.4 Sheath Blight

{*Rhizoctonia solani* (Sexual stage: *Thanetophorus cucumeris)*}

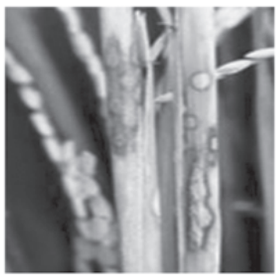
Symptoms

Fungus affect the crop from tillering to heading stage. Initial symptoms are noticed on leaf sheaths near water level. On the leaf sheath oval or elliptical or irregular greenish grey spots are formed. As the spots enlarge, the centre becomes greyish white with an irregular blackish brown or purple brown border. Lesions on the upper parts of plant extend rapidly coalescing with each other to cover entire tillers from the water line to the flag leaf.

The presence of several large lesions on a leaf sheath usually causes death of the whole leaf, and in severe cases all the leaves of a plant may be blighted. Infection extends to the inner sheaths resulting in death of the entire plant. Plants heavily infected in the early heading and grain filling growth stages produce poorly filled grain, especially in the lower part of the panicle.

Healthy leaves

Infected leaves



Infected sheath

Fig. 10.4: Symptoms of Sheath Blight

Favourable Conditions

- High relative humidity (above 95%) & high temperature (30-32°C).
- Dense planting and application of heavy doses of nitrogenous fertilizers.

Mode of Spread and Survival

The pathogen can survive as sclerotia or mycelium in dry soil for about 20 months but for 5-8 months in moist soil. It infects more than 188 crop species in 32 families. Sclerotia spread through irrigation water.

Disease Management

➲ **Cultural control**

- Avoid excess doses of nitrogenous fertilizers.
- Adopt recommended spacing and eliminate weed hosts.
- Avoid flow of irrigation water from infected fields to healthy fields.
- Deep ploughing in summer and burning of stubbles.

Notes

➲ **Biological control**

- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seed.

  Seedling root dipping with pseudomonas fluorescense 10 ml/*l* before transplanting.

- Foliar spray of pseudomonas fluorescens @ 0.2% commencing from 45 days after transplanting at 10 days interval for 3 times depending upon the intensity of disease.

➲ **Chemical control**

- Spray validamycin (3%) @ 2ml/*l* of water or propiconazole (25EC) @ 500 ml/ha.
- Spray Azoxystrobin (25SC) @ 500ml/ha along with 500 litre of water.
- Two spray of Hexaconazole (75 WG) @ 100mg/*l* water. First spray at the time of disease appearance and second spray 15 days later.

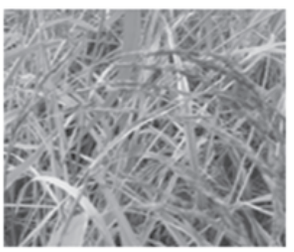
10.1.5 Grain Discolouration

Drechslera oryzae, D. rostratum, D. tetramera, Trichoconis padwickii, Sarocladium oryzae, Alternaria tenuis, Fusarium moniliforme, Cephalosporium sp., etc.

Symptoms

The grains may be infected by various organisms before or after harvesting causing discolouration, extend of which varies according to season and locality. The infection may be external or internal causing discoloration of the glumes or kernels or both. Dark brown or black spots appear on the grains. The discolouration may be red, yellow, orange, pink or black, depending upon the organism involved and the degree of infection. This disease is responsible for quantitative and qualitative losses of grains.

Discolouration of grains



Black Spots appears on grains

Fungal growth on grains

Fig. 10.5: Symptoms of grains discolouration

Favourable Conditions

- High humidity and cloudy weather during heading stage.

Notes

Mode of Spread and Survival

The disease spreads mainly through air-borne conidia and the fungus survives as parasite and saprophyte in the infected grains, plant debris and also on other crop debris.

Disease Management

➲ **Cultural control**

- Pre and post-harvest measures should be taken into account for prevention of grain discolouration.
- Drain excess water at grain filling.
- Store the grains with 13.5-14% moisture content.

➲ **Chemical control**

- Spray the crop at boot leaf stage with Mancozeb (45 wP) 0.5000g/*l* or Carbendazim @ 500g/ha.
- Spray - Carbendazim + Mancozeb (1:1) 0.2% at 50% flowering stage.

10.1.6 False smut

(*Ustilaginoidea virens)* (Syn :*Claviceps oryzae - sativa)*

Symptoms

The fungus transform individual grains into greenish spore balls of velvety appearance. Due to the development of the fructification of the pathogen, the ovaries are transformed into large velvety green masses. Usually only a few spikelets in a panicle are affected.

Healthy grain Infected panicle Infected grain

Fig. 10.6: Symptoms of false smut

Favourable conditions

- Rainfall and cloudy weather during the flowering and maturity periods are favourable.

Mode of Spread and Survival

The pathogen can survive in dry soil for about 20 months but for 5-8 months in moist soil. Conidia spread through air.

Notes

Disease Management

➲ **Cultural control**

- Adopt recommended spacing and eliminate weed hosts.

➲ **Chemical control**

- Seed treatment as described earlier.
- Two sprayings of Propiconazole (25 EC) @ 500ml/ha in 500 litre water at boot leaf and 50% flowering stage.

10.1.7 Stem Rot

(*Sclerotium oryzae)* (Sexual stage : *magnaporthe thesalvinii)*

Symptoms

Small black lesions are formed on the outer leaf sheath and they enlarge and reach the inner leaf sheath also. The affected tissues rot and abundant sclerotia are seen in the rotting tissues. The culm collapses and plants lodge. If the diseased tiller is opened, profuse mycelia growth and large number of sclerotia can be seen. The sclerotia may be seen in the stubbles after harvest.

Favourable Conditions

- Infestation of leaf hoppers and stem borer
- High doses of nitrogenous fertilizers.

Mode of Spread of Survival

The sclerotia survive in stubbles and straw are carried through irrigation water.

Disease Management

➲ **Cultural control**

- Use of recommended doses of fertilizer.
- Deep ploughing in summer and burning of stubbles.
- Avoid flow of irrigation water from infected fields to healthy fields.

➲ **Chemical control**

- Spray the crop at boot leaf stage with Mancozeb 1 kg or Iprobenphos 500 ml or Carbendazim 250 g/ha.

10.1.8 Foot Rot or Bakanae Disease

(*Fusarium moniliforme)* (Sexual stage : *Gibberella fujikuroi)*

Notes

Fig. 10.7: Tillers infected with bakane disease

Symptoms

The infected seedings in nursery are lean and lanky, much taller than healthy seedlings and die after some time. In the main field, the affected plants have tall lanky tillers and have longer internodes and aerial adventitious roots from the nodes above ground level. The root system is fibrous and bushy. Plants are killed before earhead formation or they produce only sterile spikelets. When the culm is split open white mycelia growth can be seen.

Mode of Spread and Survival

The disease is externally seed-borne.

Disease Management

- Treat the seeds with Carbendazim (50 WP) @ 2.0 g/kg.
- Uproot the seedlings in water logged condition from nursery.
- Treat the nursery area before 24 hr of uprooting with Carbendazim (50 WP) (@ 2.0 g/lit water

INTEXT QUESTIONS 10.1

1. Fill in the blanks

   (a) Node blast is ..... disease.

   (b) Seed treatment with bio-control agent *Trichoderma viride* @ ..... seed should be done.

   (c) A transformation individual grain into greenish spore velvety balls appears in ..... disease.

   (d) Azoxystrobin should be used @ ..... for the spray to control of sheath blight.

Notes

2. State True/ False

(a) High relative humidity, high night temperature and less number of rainy days are favourable condition to blast disease.

(b) Paddy grains should be stored with 13.5-14% moisture content to prevent grain discolouration.

(c) The young panicles may remain within the sheath or emerge partially in sheath rot disease.

(d) Bakanae disease is caused by *Fusarium moniliforme* fungus.

10.2 BACTERIAL DISEASE OF PADDY

Two bacterial diseases distributed widely in Asia in paddy are:

- Bacterial leaf blight, a systemic disease.
- Bacterial leaf streak, causes localised lesions.

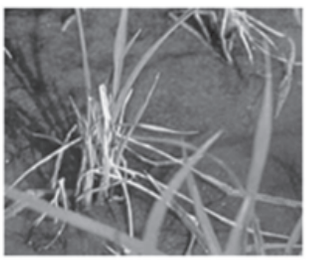
10.2.1 Bacterial Leaf Blight

(*Xanthomonas oryzae p.v. oryzae)*

Symptoms

The disease is usually noticed at the time of heading but in severe cases occur earlier also. Seedlings in the nursery show circular, yellow spots in the margin, later enlarge, coalesce and cause drying of foliage. **"Kresek"** symptom is seen in seedlings, 1-2 weeks after transplanting. The bacterium enters through the cut wounds in the leaf tips, becomes systemic and cause death of entire seedling.

In grown up plants water soaked, translucent lesions appear usually near the leaf margin. The lesions enlarge both in length and width with a wavy margin and turn straw yellow within a few days, covering the entire leaf. As the disease progresses, the lesions cover the entire leaf blade which may turn white or straw coloured. Milky or opaque dew drops containing bacterial masses are formed on young lesions in the early morning. They dry up on the surface leaving a white encrustation. If the cut end of leaf is dipped in water, bacterial ooze makes the water turbid.



Healthy leaf

Infected leaf

Fig. 10.8: Symptoms of bacterial leaf blight

Notes

Favourable Conditions

- Clipping of tip of the seedling at the time of transplanting
- Heavy rain, heavy dew, flooding, deep irrigation water, severe wind, and temperature of 25-30°C.
- Application of excess nitrogen, especially late top dressing.

Mode of Spread and Survival

The infected seeds as a source of inoculum may not be important since the bacteria decrease rapidly and die in the course of seed soaking. The pathogen survives in soil and in the infected stubbles and on collateral hosts like *Leersia spp. Planta gonajor, Paspalum dictum,* and *Cyanodon dactylon.* The pathogen spreads through irrigation water in dry season and also through rain storms.

Disease Management

➲ **Cultural control**

- Burn the stubbles and remove weed hosts.
- Use optimum dose of fertilizers.
- Avoid clipping of tip of seedling at the time of transplanting.
- Avoid flooded conditions.

➲ **Biological control**

- Spray fresh cowdung extract 20% twice (starting from initial appearance of the disease and another at fortnightly interval).

➲ **Chemical control**

- Spray Streptomycin sulphate and tetracycline combination @ 1 g + Copper oxy-chloride @ 30 g/10 litre of water.
- Streptomycin cycline @ 15g + Copper oxychloride @ 500 g/ 600 lit water/ha
- Neem oil 60 EC 3% (or) NSKE 5% is recommended for controlling bacterial blight.

10.2.2 Bacterial Leaf Streak

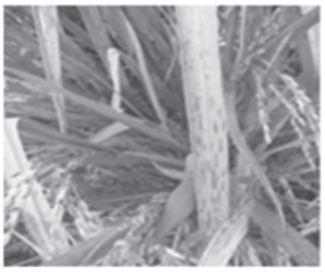
(*Xanthomonas campestrisp.v. oryzicola)*

Symptoms

Fine translucent streaks are formed on the veins and the lesions enlarge lengthwise and infect larger veins and turn brown. On the surface of leaf, bacteria ooze out and form small yellow band-like exudates under humid conditions. In severe cases the leaves may dry up.

Notes

Brown to greyish streaks on leaves



Lesions turn brown to greyish and drying of leaves

Fig. 10.9: Symptoms of bacterial leaf streak

Disease Management

- Similar to bacterial leaf blight.

10.3 VIRAL DISEASES OF PADDY

Viral diseases of paddy are transmitted by leaf hopper and plant hoppers. The important viral diseases are tungro, grassy stunt, ragged stunt, yellow dwarf and orange leaf. The viral diseases occur in almost all paddy- growing countries.

10.3.1 Tungro Disease Virus

Symptoms

Rice tungro disease is one of the most destructive viral diseases accounting for 30-100% of rice yield losses. Infection occurs both in the nursery and in the main field. Plants are markedly stunted. Leaves show yellow to orange discoloration and inter-venal chlorosis. Yellow discoloration is commonly seen in "Japonica" varieties, while "*Indica*" varieties show orange discoloration. Young leaves are often mottled with pale green to whitish inter-venal stripes. The plants may be died if infected early. The infected plants have few spikelets and panicles are small with discoloured grains.

Healthy leaf

Infected leaf

Fig. 10.10: Symptoms of tungro virus

Tungro infected plants can be chemically identified by **Iodine Test.** 10 cm long leaf tip is cut in the early morning before 6 A.M. and dipped in a solution containing 2 g iodine and

Notes

6 g Potassium iodide in 100 ml of water for 30 minutes. Tungro infected leaves show dark blue streaks.

Pathogen

It is a composite disease caused by two morphologically unrelated viruses: paddy tungro bacilliform virus (RTBV) and paddy tungro spherical virus (RTSV).

Mode of Spread and Survival

Two types of virus particles are associated with the disease. Bacilliform particles cause majority of the symptoms of the disease. Spherical particles help in the transmission of bacilliform virus by the green leaf-hoppers. If the bacilliform virus particles are alone present in the paddy plant they will not be transmitted by the leafhopper vector. The leafhoppers transmit the virus in a non-persistent manner. There is no latent period in the vector and infectivity is retained for a maximum period of 6 days after acquisition of the virus.

Disease Management

➲ **Cultural and Physical control**

- Summer deep ploughing and burning of stubbles.
- Destroy weed hosts of the virus and vectors.
- Grow disease tolerant cultivars like IR50 and CO45.
- Light traps should be set up to attract the leaf hopper vectors as well as to monitor their population.

➲ **Chemical control**

- Control vectors in the nursery by application of Carbofuran (3W) 170 g/m^2, 10 days of sowing.
- Spray Phosphamidan 500 ml or Fenthion 500 ml or Monocrotophos 1 lit/ or Thiamethoxam (25 WDG) 100g or Imidacloprid (17.8 SL) 100ml/ha or Neem oil 3 per cent in the main field 15 and 30 days after transplanting to control leaf hoppers. The vegetation on the bunds should also be sprayed with the insecticides.

10.3.2 Grassy stunt Virus

Symptoms

The infected plants are markedly stunted and have excessive tillering with an erect growth habit. The leaves become short, narrow, pale green or pale yellow and have numerous small dark brown spots. On older leaves these spots spreads and give a bronze colour to the plants. The plants may produce a few small panicles which bear dark brown and unfilled grains.

Mode of Spread and Survival

The virus is transmitted in a persistent manner by the brown plant hopper. It has a latent period of 5 to 28 days in the vector.

Notes

Disease Management

- Destroy the weed host which harbour the virus and the vectors.
- Spray Imidachlorprid (17.8 SL) 100/ha or Thiomethoam (25 WDG) or Neem oil 3% in the main field 15 and 30 days after transplanting to control leaf hoppers.

10.3.3 Paddy Dwarf Virus

Symptoms

The virus infected plants show marked stunted growth with chlorotic or whitish specks on the leaves. The size of specks varies often and form interrupted streaks along the veins and distal part of infected leaves show diffuse yellowing. The number of tillers may be reduced with retarded growth. The diseased plants may survive until harvest time, remaining more or less green. Plants which are infected at early stage produce no ear heads, if produced, may have small unfilled grains.

Favourable Conditions

- High population of sucking pests and gramineous weeds.

Mode of Spread and Survival

The virus is found to survive in the gramineous weeds. The virus is transmitted through the egg masses of leaf hoppers from one generation to another.

Disease Management

- Destroy the weed host which harbour the virus and the vectors.
- Spray Phosphamidon @ 500 ml or Fenthinon 500 ml or Monocrotophos @ 1 *l*/ha with 500 litre water.

INTEXT QUESTIONS 10.2

1. Brown leaf spot disease is caused by

   (a) Fungus (b) Bacteria
   (c) Virus (d) Nematode

2. Bacterial leaf streak disease is caused by .....

   (a) *Gibberella fujikuroi* (b) *Xanthomonas oryzae*
   (c) *Xanthomona campestris* (d) *Mycoplasma Like Organism*

3. For the control of vector of viral diseases, which one of the chemical can be used

   (a) Azoxystrobin (b) Mancozeb
   (c) Carbendazime (d) Imidaclorprid

Notes

4. **"Kresek"** symptom is seen in ..... disease.

   (a) Paddy yellow dwarf (b) Bacterial leaf blight (BCB)

   (c) Grassy stunt (d) RTSV

WHAT YOU HAVE LEARNT

Let us recapitulate and enlist salient points we have learnt through this lesson:

- Paddy diseases are classified into four groups viz., fungal, bacterial, viral and nematode, according to their causal agents. The distribution of paddy diseases in temperate and tropical regions is affected by weather factors mainly temperature and relative humidity.
- You may observe the symptoms of diseases on leaves, stem, leaf sheaths, inflorescence and grains.
- The important fungal diseases of paddy includes blast, sheath blight, sheath rot, leaf scald, bakanee, brown leaf spot, and narrow brown leaf spot and stem rot.
- Bacterial leaf blight and Bacterial leaf streak are common bacterial diseases distributed widely in Asia in paddy.
- Viral diseases of paddy are transmitted by leaf hopper and plant hoppers. The important viral diseases are tungro, grassy stunt, ragged stunt, yellow dwarf and orange leaf. The viral diseases occur in almost all paddy- growing countries.
- Integrated Disease Management (IDM) is a holistic approach, in which all possible methods (cultural, biological and chemical) are unified in way to control the disease(s) with least harmful effect on environment and to minimize the ill effect of chemicals.

TERMINAL EXERCISE

1. Name major diseases and their causal organism of paddy.
2. Discuss the symptoms and control measures of bacterial leaf blight and sheath blight.
3. Explain the symptoms, favourable conditions and management of blast disease.
4. Write name of causal organism of following diseases.

   (a) Sheath rot (b) Brown spot

   (c) Bacterial leaf blight (d) Bacterial leaf streak

5. Explain management of viral diseases in paddy.

Notes

6. Define IDM. Explain IDM for
   (a) Brown spot (b) Sheath rot
   (c) Sheath blight (d) Grain discoloration
   (e) False smut

ANSWERS TO INTEXT QUESTIONS

10.1

1. (a) fungal (b) 5-10gm/kg (c) false smut (d) 500 ml/ha

2. (a) False (b) True (c) True (d) True

10.2

1. (a) Fungus 2. (c) *Xanthomonas campestris*
3. (d) midachlorprid 4. (b) BLB

11

HARVESTING AND POST HARVEST MANAGEMENT

In the previous lesson, we have learnt and practiced all the cultural operations right from selection of seeds to paddy growing. The crop now fully grown and is ready to harvest. The collection of mature rice crop from field, is called harvesting. Harvesting and post harvest management of rice consist of the basic operations which can be done in individual steps or in combination by using a combine harvester. These include:

- Reaping - cutting the mature panicles and straw above ground
- Hauling - moving the cut crop to the threshing location
- Field drying - leaving the cut crop in the field and exposing it to the sun for drying (optional)
- Stacking/piling - temporarily storing the harvested crop in stacks or piles (optional)
- Threshing - separating the paddy grain from the rest of cut crop
- Winnowing and cleaning - removing immature, unfilled, non-grain materials
- Bagging - putting the threshed grain in bags for transport and storage

You might have seen or practiced few traditional harvesting activities such as field drying and stacking/piling. These activities are scientifically not recommended because they can lead to rapid quality deterioration and increased harvest losses. Besides these, other activities that can be included in harvesting are gathering, reaping (gathering standing grain by cutting), bundling, and various forms of transporting the crop and grain.

OBJECTIVES

After reading this lesson, you will be able to:

- identify the correct stage of harvesting paddy;
- collect the quality paddy from field;

Notes

- thresh the harvested paddy grains;
- dry the paddy grains for safe storage;
- perform winnowing and cleaning of grains;
- pack and store paddy grains safely;
- protect the grains from insect pests in storage.

11.1 METHODS OF HARVESTING

The manual method of harvesting paddy is termed as traditional harvesting. But this method requires large number of labour and more time which result in delay of successive crop. The combine are developed for mechanized harvesting of paddy which combines all operations into one. Both manual and combine methods are used in India.

11.1.1 Manual Harvesting

This system is the most common means of paddy harvesting. The paddy crop is cut by using simple hand tools like *sickle* (best for cutting 15-25 cm above ground level), and *hand-held knives* (best for cutting just below the panicle). When cutting crop with a sickle, always hold stems with thumb pointing upwards, away from the blade. The mature panicle along with straw of paddy are harvested and collected at one place in the field.

Advantages

This method is very effective in lodged crop conditions.

Disadvantages

Labour-intensive, requires 25-30 man days per hectare. It will take additional labour to manually collect and haul the harvested crop.

Fig. 11.1: Manual harvesting of paddy

11.1.2 Combine Harvesting

It combines several operations into one i.e. cutting the crop, feeding it into threshing mechanism, threshing, cleaning, and discharging grain into a bulk wagon or directly into bags. Straw is usually discharged behind the combine in a windrow.

Fig. 11.2: Paddy harvesting by use of combine harvester

11.2 HARVESTING STAGE

Manual harvesting

The right stage of manual harvesting of paddy is just when the ears are nearly ripe and the straw has just turned yellow. Delay harvesting leads to loss of grain due to shattering and it also affects milling quality of the grain.

Combine Harvesting

In case of combine harvesting the stage of crop is very important. The time interval for harvesting by combine harvester is often narrow: too early harvesting will result in a high percentage of immature kernels, and too late harvesting will result in high shattering losses. The crop should be harvested at stage of crop given below:

- When the moisture content in grains is 20-25%, or
- When 80% of the grains become straw coloured, or
- At least 20% of the grains at the panicle base have reached hard dough stage.

11.3 THRESHING

If you have harvested your crop manually, it is advisable to thresh it as soon as possible and not leave the harvested crop in field exposed to sun. If it has to be left for some time in field, cover the heap properly. Threshing can be done either by beating the sheaves against some hard surface (drums) just after harvesting or by allowing the bullocks to tread on well dried plants. For big farms pedal threshers or power threshes are also available for use.

INTEXT QUESTIONS 11.1

1. The manual harvesting of rice crop should be done from ..... cm above ground level.
2. At the time of harvesting the moisture content in grains are ..... %.

Notes

3. The tool used in manual harvesting of paddy is .....

4. The delay in harvesting time results in ..... losses.

11.4 DRYING OF GRAINS

Drying is the most critical operation after harvesting a paddy crop. It reduces grain moisture content to a safe level for storage. When paddy is harvested, it contains up to 25% moisture. High moisture level during storage can lead to grain discoloration, encourage development of moulds, and increase the attack of stored grain pests. It can also decrease the germination rate of the paddy seeds.

It is important to dry paddy grain as soon as possible after harvesting ideally within 24 hours. Delays in drying, incomplete drying or ineffective drying will reduce grain quality and result in losses.

Paddy drying methods include traditional and mechanical systems with varying technological complexity and capacities for either farm or commercial level.

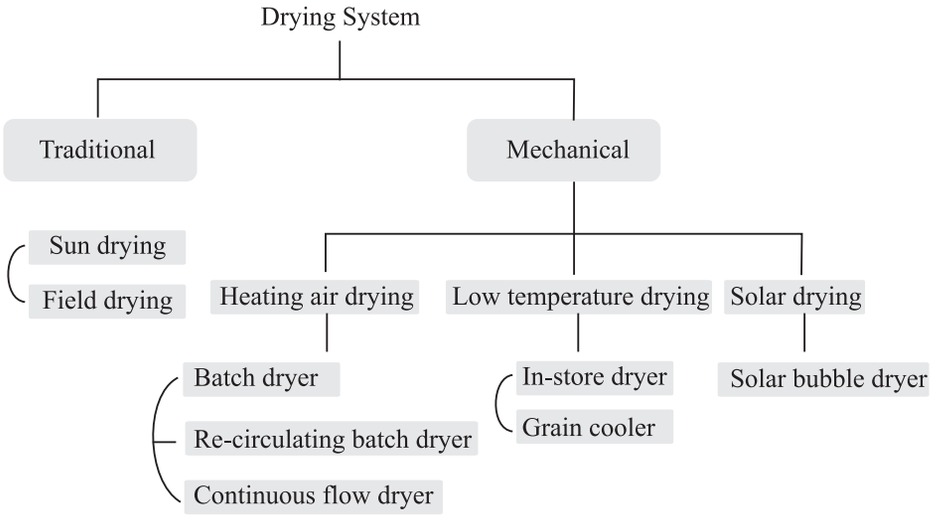


Fig. 11.3: Paddy drying methods

11.4.1 Traditional Drying

Traditional drying methods are still practiced in many areas because of its low cost and ease of management. These include methods, such as:

(i) Sun drying - spreading grains under the sun on mats and pavements

- Mat drying - used in small to medium-scale drying where threshed grain are placed on mats, nets, or canvas.
- Pavement drying - often used in large-scale drying for grain collectors and millers, where grains are laid on pavements specifically made for drying

Notes

(ii) Field drying and stacking - a method for pre-drying hand harvested crops before threshing where rice panicles are cut in the field and stacked in small piles on top of the crop stubble.

11.4.2 Guidelines for Drying

- Properly dried seeds produce high-quality grains.
- Clean the grains before drying to avoid uneven drying and wet spot.
- Dry paddy grains within 12– 24 hours after cutting as even short-term storage of high moisture grain can cause quality deterioration.

Table 11.1: Grains should be dried to certain moisture content (MC) depending on storage period to avoid potential problems

Storage period	Required MC for safe storage	Potential problems
weeks to a few months	14% or less	Moulds, discoloration, respiration loss insect damage, moisture adsorption
8–12 months	13% or less	insect damage
storage of farmer's seeds	12% or less	loss of germination
<1 year	9% or less	loss of germination

Note: The final moisture content depends on the relative humidity of the air that surrounds the grain. For long-term storage of grain and seed in tropical climates, it is crucial to prevent rewetting of grain by humid air.

11.5 WINNOWING AND CLEANING

Winnowing removes lighter materials such as unfilled grains, chaff, weed seeds and straw remains. This is done by using a blower, air fan or by wind. Recover only the heavier, healthy and good quality grains after winnowing. If you do not clean your rice properly, you may face problems. Rice with impurities will deteriorate during storage, reduce head rice yield, damage your milling machine and increase weight & bulkiness during handling.

Traditional paddy cleaning: In traditional paddy cleaning, rice crop is beaten by two or three persons on wooden logs. After collecting the rice in big baskets, these are raised above the head by a person standing on a self-made bamboo-frames platform to clean husk and impurities from rice.

Notes

Hand Operated Winnower: It is a machine that uses fan blades, chain and sprocket arrangement to enable fan operations faster with little effort. Weighing around 29 kg, the Hand Operated Winnower is provided with a fan guard to prevent any accident.

11.6 PACKAGING AND STORAGE

The purpose of any grain storage facility is to provide safe storage conditions for the grain in order to prevent grain loss caused by adverse weather, moisture, rodents, birds, insects and micro-organisms like fungi.

In general, it is recommended that rice for food purposes be stored in paddy form rather than milled rice as the husk provides some protection against insects and helps prevent quality deterioration. However, when rice can be stored as brown rice, 20% less storage capacity will be needed. Brown rice is rice grain with its hulls removed but not polished. Under tropical conditions brown rice has a very short shelf life, approximately two weeks.

Storage can be done through bag, bulk, or hermetic containers.

- Bag storage- Grain is stored in 40-80 kg bags made from either jute or woven plastic.
- Bulk storage - Grain is stored in bulk at the farm or at commercial collection houses.
- Hermetic storage - Grain is stored in an airtight container so that the moisture content of the stored grain will remain same as when it was sealed. These storages can extend germination life of seeds, control insect grain pests, and improve head rice recovery.eg. IRRI Superbag- This is available to farmers and processors at low cost; Cocoon-Commercially available; Other locally available containers- Useful in rural settings, where local containers can be easily converted into hermetic storage systems.

You should examine the storage system for the following qualities:

- Protection from insects, rodents and birds.
- Ease of loading and unloading.
- Efficient use of space.
- Ease of maintenance and management.
- Prevention of moisture re-entering the grain after drying.

You may increase safe storage life of rice by the following three conditions:

1. Grain is maintained at moisture levels of 14% or less and seed is stored at 12% or less.
2. Grain is protected from insects, rodents and birds.
3. Grain is protected from re-wetting by rain or imbibing moisture from the surrounding air. The longer grain needs to be stored, the lower moisture content will required. Grain and seed stored at moisture contents above 14% may experience the growth of moulds, rapid loss of viability and a reduction in the quality.

INTEXT QUESTIONS 11.2

1. The optimum moisture content (%) of grain for storage is

   (a) 20 (b) 25

   (c) 14 (d) 5

2. At the time of harvest the paddy grains contain moisture (%) is

   (a) 18 (b) 25

   (c) 15 (d) 35

3. Traditional methods of drying are ..... and .....

4. High moisture level during storage can lead ..... and .....

WHAT YOU HAVE LEARNT

Let us recapitulate and enlist salient points we have learnt through this lesson:

- Harvesting rice consists of the basic operations include: reaping, threshing, cleaning, hauling, field drying, stacking/piling and bagging.
- The crop should be harvested when the moisture content in grains is 20-25%, or 80% of the grains become straw coloured, or at least 20% of the grains at the panicle base have reached hard dough stage.
- Traditional harvesting of paddy is done manually. The combine are developed for mechanized harvesting of paddy which combines all operations into one.
- Drying reduces grain moisture content to a safe level for storage. It is the most critical operation after harvesting a rice crop. It is important to dry rice grain as soon as possible after harvesting ideally within 24 hours. Delays in drying, incomplete drying or ineffective drying will reduce grain quality and result in losses.
- Storage facility is required to provide safe storage conditions for the grain in order to prevent grain loss caused by adverse weather, moisture, rodents, birds, insects and micro-organisms like fungi.

TERMINAL EXERCISE

1. How will you identify the harvesting stage of paddy.
2. What are the common paddy harvesting methods practised in India? Give their advantages and disadvantages.

Notes

3. Explain drying of paddy grains.
4. Write down the storage methods of paddy produce.
5. What is the role of moisture content on safe storage of paddy grains?
6. How the winnowing and cleaning of paddy may be done?
7. Describe the conditions for safe rice storage.

ANSWERS TO INTEXT QUESTIONS

11.1

1. 15-25
2. 20- 25
3. sickles
4. yield

11.2

1. (c) 14
2. (b) 25
3. sun drying; field drying
4. grain discoloration; encourage development of molds

Notes

12

STRAW MANAGEMENT

The only organic matter available in significant quantities after harvesting of paddy is the Straw. About 40 percent of the nitrogen (N), 30 to 35 percent of the phosphorus (P), 80 to 85 percent of the potassium (K), and 40 to 50 percent of the sulphur (S) taken up by paddy remains in vegetative plant parts at crop maturity. Straw is also an important source of micronutrients such as zinc (Zn).

Straw is removed from the field, burned in situ, piled or spread in the field, incorporated in the soil, or used as mulch for the next crop. Each of these measures has a different effect on overall nutrient balance and long-term soil fertility.

A major portion of this agricultural waste is disposed off by burning or is mulched in the rice fields. These wastes, if not properly handled, will cause many problems to you as well as to the environment. If paddy straw is left in the field without proper management, it can cause spreading stem disease, and can also encourage the breeding of pests, especially rats. Burning is not the right way to deal with such waste, as it is harmful to the environment, soil microbes, human health, and also increases global warming.

OBJECTIVES

After reading this lesson, you will be able to:

- explain harmful effects of paddy straw burning;
- learn different methods of straw management;
- discuss the effect of straw on soil fertility status.

12.1 HARMFUL EFFECT PADDY STRAW BURNING

Burning of paddy straw causes enormous harmful effects. Few are mentioned below:

- Burning causes almost complete N loss, P losses of about 25 percent, K losses of 20 percent, and S losses of 5 to 60 percent from the burnt straw.

Notes

- Burning decreases the population of microorganism in soils which affect the availability of nutrients to the crop plant. Burning also results in loss of beneficial insects in the soil.
- One tone of straw or carbon burning releases 1.6 tonnes of CO_2 which increases the environment temperature directly.
- CO_2 affects the ozone layer resulting in global warming. The global worming results in melting of ice in polar region that increases the sea level.
- Smoke produced by burning creates irritation in eyes.
- Burning causes atmospheric pollution. Smoke from agricultural burning is released at or near ground level in areas that are generally populated, producing direct, intense exposure to pollutants for the nearby populations.
- Visibility in nearby areas and highways is affected.

12.2 METHODS OF STRAW MANAGEMENT

Straw Removal

Removal of straw from the field is widespread in India, Bangladesh, and Nepal, which explains the depletion of soil Potassium (K) and Silicon (Si) reserves at many sites. In manual harvesting and threshing the straw can be directly obtained after threshing of paddy grains by cutting the residues. The straw can be removed from fields harvested by combines with the help of straw reapers. The straw reaper collects the leftover residues from field and converts it into straw.

This collected straw can be used as fuel for cooking, ruminant fodder, and stable bedding or as a raw material in industrial processes (e.g., papermaking).

Straw Incorporation

Incorporation of the remaining stubble and straw into the soil returns most of the nutrients and helps to conserve soil nutrient reserves in the long term. Short-term effects on grain yield are often less (compared with straw removal or burning) but long-term benefits are significant. Where mineral fertilizers are used and straw is incorporated, reserves of soil N, P, K, and Si are maintained and may even be increased.

The main advantages of rice straw incorporation into the soil are to (1) minimize cost of cultivation, (2) maximize decomposition during winter, (3) minimize disease risk and (4) avoid yield loss in the next growing season.

Transplanting in succeeding crop should be carried out two to three weeks after straw incorporation. The early, dry shallow tillage at 5 to 10 cm depths (to incorporate crop residues and enhance soil aeration during fallow periods) has beneficial effects on soil fertility in intensive rice-rice systems.

Beneficial effects of straw incorporation during fallow period are:

- A complete carbon (C) turnover is achieved by aerobic decomposition of crop residues (about 50 percent of the C within 30 to 40 days), thereby minimizing negative effects (e.g. phytotoxicity) of the products of anaerobic decomposition on early rice growth.
- Improved soil aeration, i.e. re-oxidation of iron (Fe^{2+}) and other reduced substances that accumulate during the flooding period.
- Increased nitrogen mineralization and soil phoshorus release to the succeeding crop, up to the panicle initiation stage.
- Reduced weed growth during the fallow period.
- Reduced irrigation requirement during land preparation (i.e. less soil cracking and bypass flow water losses in heavy clay soils).
- Easier wetland preparation (i.e. there is often no need for a second ploughing operation).
- Smaller methane (CH_4) emissions compared with straw incorporation during land preparation for the crop.

Table 12.1: Average nutrient content (%) and amounts removed with 1 tone of straw residue

	N	P_2O_5	K_2O	S
Content in straw, % dry matter	0.5-0.8	0.16-0.27	1.4-2.0	0.05-0.10
Removal with 1 tone straw, kg/ha	5-8	1.6-2.7	14-20	0.5-1.0

Disadvantages

- In case of wet incorporation of straw and stubble into wet soil (during ploughing) results in temporary immobilization of N and a significant increase in methane (CH4) emission from paddy, a practice that contribute to greenhouse gases.
- Incorporation of large amounts of fresh straw is either labour-intensive or requires suitable machinery for land preparation and may result in the build-up of disease problems.

Keeping them on Surface

The paddy straw lefts in the field after harvesting is done with combine harvester. This straw could be kept on surface by sowing of next crop with the help of happy seeder and zero tillage machines. The main advantages of this method are:

- It adds carbon in the soil and increases the biological activity in top soil.
- It also helps in temperature moderation. It keeps soil cool in summer and hot in winter that promots the plant growth.

Notes

Use in Mushroom Production

Paddy straw can be used as the main substrate for mushroom cultivation. For this, it should be composted first. Chicken manure, rice bran, urea, and gypsum may be mixed with the straw, to improve its nutrient content. For each ton of dry paddy straw, approximately 100 kg of chicken manure, 50 kg of rice bran, 12-15 kg of urea, and 10 kg of gypsum are required. The paddy straw is prepared by pasteurized composting.

Fig. 12.1: Mushrooms growing in the paddy straw compost

Method of Compost Preparation

Pre-Wetting: Dry paddy straw is cut in to a length of 10 - 20 cm, and soaked with water (for 2 - 3 days in spring, six months after the straw has been cut, and 1-2 days in autumn, immediately after the rice harvest).

Fig. 12.2: Pre-wetting the paddy straw

Stacking and Turning

The compost must be stacked and left to mature for 15 - 20 days in autumn, and 20 -25 days in spring. During this time, compost must be kept moist and turned repeatedly.

The purpose of turning the compost is to make sure that the materials are thoroughly mixed, and that there is even moisture content throughout the stack. Turning also helps regulate the temperature. When the temperature in the centre of the stack rises to more than 70 0C, the compost should be turned.

Pasteurization and Conditioning

Once the compost has been put in the bed for mushroom production, it should be pasteurized by allowing the heat to rise to 58 – 60°C for 4 - 6 hours. Afterwards, the temperature should be kept at 48 - 55°C for 6 - 8 days, to allow the compost to mature.

After harvesting or milling, the straw or rice husks are placed in piles. Consider the following tips for preparing the compost:

- There should be adequate N supply, moisture content and abundant microorganisms.
- The composting site should be levelled; well drained and under shade. The compost materials should be chopped into small pieces (3-5 cm) for good result.
- If possible, compost heaps should be built in layers consisting of cereal crop material {wider Carbon: Nitrogen (C:N ratio)} combined with legume or manure wastes (higher N content) and mix in a ratio of 2:1 (cereal: legume/manure). Many farmers leave paddy straw in large piles where it lands after threshing, but this should be avoided as it results in compost with lesser nutrient content.
- Compost heaps should be kept moist; not too wet (no water draining from the compost pile) and not too dry (straw so dry it cracks when bent).
- To aid decomposition, sprinkle your compost heap with decaying material (e.g. cow dung slurry, cow urine), a dilute solution of nitrogen fertilizer (such as urea) and/or with a micro-organism solution (e.g., *Trichoderma harzianum*). Such additives are desirable because they contain nitrogen and/or microorganisms that aid decomposition.
- It is best to mix and turn the compost heaps every two weeks.
- Compost will be ready within 4-8 weeks, if moisture and temperature are favourable.

Microorganism rich composting

It is the composting of paddy straw with mixing of effective microorganisms which contains lactic acid bacteria, yeast and phototrophic bacteria. The compost product is rich in microorganism.

Advantages of compost

1. Compost contains a range of micronutrients and microorganisms (that are absent in inorganic fertilizers) and are beneficial to crop growth and soil health.
2. Nutrients in compost are released slowly and are less likely to be lost by leaching.
3. The high temperatures generated in composting (above 55oC) keep pathogen levels low and reduce the viability of weed seeds contained in the compost material.
4. Once compost is ready to use, it is fairly stable and has little odor.
5. Organic wastes are widely available on farms.

INTEXT QUESTION 12.1

1. Burning cause ..... nitrogen loss and phosphorus losses of about .....%.
2. The content of nitrogen (N) in dry paddy straw ranges ..... between ..... %.

Notes

3. One tone of straw or carbon burning releases ..... tones of CO_2.

4. Compost heaps consisting of cereal crop material (wider C:N ratio) is combined with legume or manure wastes (higher nitrogen content) in the ratio of .....

WHAT YOU HAVE LEARNT

Let us recapitulate and enlist salient points we have learnt through this lesson:

- Straw is either removed from the field, burned in situ, piled or spread in the field, incorporated in the soil, or used as mulch for the next crop.
- Burning straw causes almost complete N loss, P losses of about 25 percent, K losses of 20 percent, and S losses of 5 to 60 percent.
- Burning paddy straw decreases the population of microorganisms in soil and also results in loss of beneficial insects in the soil.
- The incorporation of rice straw into the soil minimizes the cost of cultivation, maximize decomposition during winter, minimize disease risk and avoid yield loss in the next growing season.
- Paddy straw can be easily managed by incorporating them in soil, preparation in mushroom compost and for making microorganism rich compost/manure etc.

TERMINAL EXERCISE

1. Write down the harmful effects of burning paddy straw.
2. What are the methods of straw management in situ?
3. Write down the use of paddy straw after removal from field.
4. Write down the beneficial effects of straw incorporation during fallow period.
5. How the paddy straw is used in mushroom production?
6. Explain the benefits of paddy compost.

ANSWERS TO INTEXT QUESTIONS

12.1

1. complete; 25
2. 0.5-0.8
3. 1.6
4. 2 :1

13

MAINTAIN HEALTH AND SAFETY

Pesticides are widely used throughout the world in agriculture to protect the crops and in public health to control diseases. Nevertheless exposure to pesticides can represent a potential risk to humans. Pesticide manufacturing unit workers are prone to possible occupational pesticide exposure. The relationship between extent of pesticide use and signs and symptoms of illnesses due to exposure was assessed in several cross-sectional surveys.

Use of pesticides in India began in 1948 when DDT was imported for malaria control and BHC for locust control. India started pesticide production with manufacturing plant for DDT and benzene hexachloride (BHC/ HCH) in the year 1952. In 1958, India was producing over 5000 metric tons of pesticides. Currently, there are approximately 145 pesticides registered for use, and production has increased to approximately 85,000 metric tons. Rampant use of these chemicals has given rise to several short-term and long-term adverse effects of these chemicals. The first report of poisoning due to pesticides in India came from Kerala in 1958 where, over 100 people died after consuming wheat flour contaminated with parathion. Despite the fact that the consumption of pesticides in India is still very low, about 0.5 kg/ha of pesticides against 6.60 and 12.0 kg/ha in Korea and Japan, respectively, there has been a widespread contamination of food commodities with pesticide residues, basically due to non-judicious use of pesticides. In India, 51% of foods commodities are contaminated with pesticide residues and out of these, 20% have pesticides residues above the maximum residue level values on a worldwide basis. It has been observed that their long-term, low-dose exposure are increasingly linked to human health effects such as immune-suppression, hormone disruption, diminished intelligence, reproductive abnormalities, and cancer.

OBJECTIVES

After reading this lesson, you will be to:

- aware of harmful effects of agro-chemicals;
- avoid accidents during the application of pesticides;

Notes

- use pesticides judiciously;
- take precautions during agrochemicals application.

13.1 HARMFUL EFFECTS OF AGRO-CHEMICALS

The harmful health effects of different agro pesticides used in paddy crop are as under:

Chemical	Use	Harmful effect
Phorate	A systemic and contact insecticide employed for the control of aphids other sucking pests	Cholinesterase inhibition and the associated neurological and neuromuscular effects
Malathion	Widely used insecticide and acaricide used for the control of aphids, thrips, stem borer and leafhoppers	Malathion and its oxygen analog malaoxon are both quite carcinogenic and have been linked with increased incidence of leukemia in mammals. Chronic health effects include: suspected mutagen and teratogen, delayed neurotoxin, allergic reactions, behavioral effects, ulcers, eye damage, abnormal brain waves and immuno-suppression
Monocrotofos	A powerful contact and systemic insecticide and acaricide with a broad spectrum of activity used to control major pests	Monocrotophos has also been shown to cause delayed neuropathy
Dimethoate	A systemic and contact insecticide and acaricide, effective against hoppers and thrips	Dimethoate might have carcinogenicity, birth defects, reproductive toxicity and mutagenic effects
Chlorpyrifos	A broad spectrum insecticide used against rice weevil, leaf folder, stem borer	Chloropyriphos has chronic neurobehavioral effects like persistent headaches, blurred vision, unusual fatigue or muscle weakness, and problems with mental function including memory, concentration, depression, and irritability.
Quinalphos	A broad spectrum contact and systemic insecticides applied as a spray to control major pests	Anti-choline esterase
Acephate	It is a systemic insecticide effective against chewing and sucking pests	Carcinogenic and mutagenic effects and reproductive toxicity

Notes

Carbaryl	It is a contact insecticide with a broad spectrum of activity effective against many major pests	Carbaryl may cause mutations (genetic changes) in living cells. It is a possible teratogen & may damage the kidneys and nervous systems
Carbofuran	It is a broad spectrum systemic insecticide, acaricide and nematicide used against insects, mites and incorporated in soil for control of soil insects and nematodes	Carbofuran causes cholinesterase inhibition in both humans and animals, affecting nervous system function
Butachlor	It controls annual grasses and some broad leaved weeds in transplant and direct seeded rice. It is applied as pre-emergence in EC formulations and as early post emergence in the form of granules	Weight loss, weight changes in internal organs, reduced brain size together with lesions
Glyphosate	It is a potent non-selective post emergence herbicide which kills mono and dicotyledonous annual and perennial weeds	No adverse effects
Isoproturon	It is used to control annual grass weeds	Isoproturon is a tumour promoter
Mancozeb	It is a protective fungicide, effective against a wide range of foliage disease	Ethylenethiourea (ETU) in the course of mancozeb metabolism and production has the potential to cause goiter, a condition in which the thyroid gland is enlarged, this metabolite has produced birth defects and cancer in experimental animals
Captan	It is a foliage fungicide with protective action. It is mainly used for seed treatment and soil fungicide	Captan is a possible carcinogen and mutagen
Captafol	It is a protective, wide spectrum foliage and soil fungicide	Captafol has oncogenic potential (potential to cause cancer)
Carbendazim	It is a systemic fungicide which controls wide range of pathogens and very effective against bakanae disease	Carbendazim is also a teratogen - damaging development of mammals in the womb

13.2 MAXIMUM RESIDUE LEVEL (MRL)

The traces pesticides leave in treated product are called residues. The amount of residue of the toxicant that can be permitted to be present in / on the produce used by man and animals is called tolerance limits. It is expressed in ppm. The residues should not exceed than the tolerance limits when offered for consumption. It is a measure of safety against the harmful effects of pesticide.

Notes

When pesticide residues persist more than their prescribed MRL in fruits and vegetables, washing the contaminated fruits and vegetables could dislodge the residues to the extent of 20-25 % with water, 20-35 % with dilute solutions of salt, 40-60 % with detergent solutions and 40-100 % by peeling the fruit skin , processing and cooking. Maximum residue level (MRL) is the highest level of a pesticide residue that his legally tolerated in or on food when pesticides are applied correctly.

- The amount of residues found in food must be safe for consumers and must be as low as possible.
- The European commission fixes MRL for all food and animal feed.
- The MRL for crops and all pesticides can be found in the MRL database on the commission.

Table 13.1: Maximum Residue Level (MRL) value of pesticide on Rice:

Pesticide	MRL(mg/kg)
Carbaryl	2.5
Cartap hydrochloride	0.50
Ediphenphos	0.02
Hexachlorocyclohexane (HCH) Alpha-isomer	0.10
Hexachlorocyclohexane (HCH) Beta-isomer	0.10
Hexachlorocyclohexane (HCH) Gamma-isomer	0.10
Hexachlorocyclohexane (HCH) Delta-isomer	0.10
Methyl chloro-phenoxyacetic acid (MCPA)	0.05
Oxadiazon	0.03
Primiphos-methyl	0.50
Quinalphos	0.01

13.3 SAFETY MEASURES DURING CHEMICAL APPLICATION

As pesticide application is a major activity in the use of agrochemicals and also the most hazardous, precautions to be taken before, during and after application are treated separately.

13.3.1 Pre-spraying Precautions

1. Mixing and loading operations are the most hazardous because they generally result in possibilities of exposure i.e. spills.

Notes

2. Read label for carrying out the necessary calculations for the required dilution of the insecticide.
3. Obtain proper equipments, including protective clothing, etc.
4. Never work alone while handling highly hazardous insecticides.
5. Mix insecticides outside or in a well ventilated area. Never position any part of the body directly over the seal while opening. Always stand upwind when mixing or loading the insecticides.
6. Clean up spilled insecticide immediately from skin, clothing etc.
7. Persons engaged in handling, mixing or applying insecticides should not smoke, eat or drink while working.
8. Do not use mouth to siphon an insecticide from the container.
9. Guard against drift of insecticides on to nearby crops, field, fish pond, stream or livestock.
10. Do not spray when it is windy.
11. Do not spray or dust when it is likely to rain.
12. Best time for spraying is evening.
13. Do not use poor quality or leaky equipment.
14. Never allow children to apply insecticides.
15. Do not blow out the clogged nozzles with the mouth.
16. Proper cleaning and maintenance of insecticide application equipments.
17. Keep separate sprayers for herbicides.

3.3.2 Safety during Application

1. Do not eat, drink or smoke during application operation and later do these only after washing hands and face thoroughly.
2. Never leave insecticides and equipments unattended in the field.
3. The insecticides should always be stored in their original containers and kept in a locked cupboard where they are out of reach of the children and the domestic animals.
4. These should be kept away from food or feed stuffs and medicines.
5. Instructions found on the labels should be carefully read and strictly followed.
6. The empty containers, after the use of the insecticide, should be destroyed and should not be put into some other use.

Notes

7. Persons engaged in handling insecticides should undergo regular medicinal check-up.

8. In case of any suspected poisoning due to insecticides, the nearest physician should be called immediately.

Fig.13.1: Pouring from large containers with the spout uppermost

13.3.3 Post-spraying Precautions

1. Thoroughly wash hands, face and neck as well as other parts of the body which may have been contaminated. If gloves have been worn, wash them before removal.

2. Return unused agrochemicals to safe storage and safely dispose of empty containers and any surplus in the application equipment.

3. Decontaminate application equipment by washing it thoroughly. The washings should be drained into a soak-away or similar chamber to be safely confined and without risk to the environment.

4. Decontaminate protective clothing by thoroughly washing items such as apron, boots and face shield. Launder the work clothing each day after spraying. Gloves should be washed inside and out and allowed to dry. Respiratory protection equipment should be wiped clean.

5. Bath thoroughly after completing the above actions.

6. Maintain a record book to provide information about the agrochemicals used, the date, place of use and the name of the user. This is both good management practice and also a source of reference in the event of agrochemical-related illness.

7. Burn the empty containers used while agrochemical applications.

Notes

Fig.13.2: Burning agrochemical containers

INTEXT QUESTIONS 13.1

1. Full form of MRL is .....
2. Monocrotofos is dangerous for ..... body organ.
3. First time in India BHC is used for ..... insect.
4. MRL value for carbaryl is ..... (mg/kg).
5. Best time of agrochemical spraying is .....

13.4 SYMPTOMS OF INSECTICIDE POISONING

3.4.1 Symptoms of Mild Poisoning

1. Headache
2. A feeling of sickness (nausea)
3. Dizziness
4. Fatigue
5. Irritation of the Skin, Eyes, Nose and Throat,
6. Perspiration
7. Loss of appetite

3.4.2 Symptoms of Moderate Poisoning

1. Vomiting
2. Blurred vision

Notes

3. Stomach cramps
4. Rapid pulse
5. Difficulty in breathing, constricted pupils of the eyes
6. Excessive precipitation
7. Trembling and twitching of muscles, fatigue and nervous distress headache

3.4.3 Symptoms of Severe Poisoning

1. Convulsions
2. Respiratory failure
3. Loss of consciousness
4. Loss of pulse

13.5 FIRST AID AND ANTIDOTS FOR INSECTICIDE POISONING

In case of pesticide poisoning CALL A PHYSICIAN IMMEDIATELY. While awaiting the physician's arrival, apply the First Aid.

3.5.1 First Aid

Swallowed poisons

(i) Remove poison from the patient's stomach immediately by inducing vomiting. For this, make a solution of common salt with one tea spoonful (15 g) in a glass of warm water as an emetic and repeat until the vomit fluid is clear. Gentle stroking or touching the throat with a finger or placing the blunt end of the spoon will help to induce vomiting when the stomach is full of fluid.

(ii) If the patient is already vomiting do not give common salt in warm water but give large amount of warm water and follow the specific directions as suggested above.

Inhaled poisons

(i) Carry the patient (do not let him walk) to fresh air immediately.

(ii) Open all doors and windows.

(iii) Loosen all the tight clothing.

(iv) Apply artificial respiration if breathing has stopped or is irregular; avoid vigorous application of pressure to the chest.

(v) Prevent chilling.

(vi) Cover the patient with a blanket.

(vii) Keep the patient as quite as possible.

Notes

(viii) If the patient is convalescing, keep him in bed in some dark room.

(ix) Avoid any jeering noise.

(x) Do not give alcohol in any form.

Skin Contamination

(i) Drench the skin with water (giving a shower or with a hose or pump).

(ii) Apply a stream of water on the skin while removing clothing.

(iii) Clean the skin thoroughly with water.

(iv) Rapid washing is most important for reducing the extent of injury.

Eye Contamination

(i) Hold eye lids open.

(ii) Wash the eyelid gently with stream of running water immediately. A delay of even a few seconds greatly increases the extent of injury.

(iii) Continue washing until the physician arrives.

(iv) Do not use any chemical as may increase the extent of injury.

Fig. 13.3: Wash exposed parts of the body thoroughly

Prevention of Collapses

(i) Cover the patient with a light blanket.

(ii) Do not use a hot water bottle.

(iii) Raise the feet of the patient on the bed.

(iv) Apply elastic bands to arms and leg.

Notes

(v) Give strong tea or coffee.

(vi) Give hypodermic injections of stimulants, such as caffeine and epinephrine.

(vii) Give fluid administration of dextrose 5 % intravenously.

(viii) Give blood or plasma transfusion.

(ix) Do not exhaust the patient by too much or too vigour's treatment.

3.5.2 Antidotes

General antidotes

1. Remove poison by inducing vomiting.
2. Universal Antidote: It is a mixture of 7 g of activated charcoal, 3.5 g of magnesium oxide and 3.5 g of tannic acid in half a glass of warm water. This may be used to absorb or neutralize poisons.
3. Removal of stomach contents (Gastric lavage).
4. Demulcents : After removal of stomach contents as completely as possible, give one of the following:
   - Raw egg white mixed with water
   - Gelatine 9 g to 18 g dissolved in 570 ml of warm water
   - Butter
   - Cream
   - Milk or Mashed potato

Specific Antidotes:

1. Atropine is the usual antidote for organophosphate and carbamate poisoning. It can be given orally and in severe cases, injections are given. Repeated injections may be required.
2. 2 PAM: It is injected intravenously as an antidote in organophosphate poisoning. It should not be used in case of carbamate poisoning.
3. Calcium gluconate is recommended as an antidote for some organochlorine insecticides.
4. Vitamin K is the preferred antidote for anticoagulant poisoning such as warfarin.
5. Dimercaprol (BAL) is recommended for arsenic poison.

INTEXT QUESTIONS 13.2

1. ..... is best after swallowing the poison.
2. ..... antitode is preferred for anticoagulant poisoning.

Notes

3. ..... is recommended for arsenic poison.

4. Respiratory failure and Loss of pulse are the symptoms of ..... poisoning.

5. Removal of stomach contents is also known as .....

13.6 SAFETY MEASURES FOR DIFFERENT CULTURAL OPERATIONS

Follow the safety precautions during different cultural operations like sowing, transplanting, weeding, harvesting etc. Few are mentioned below:

- During sowing period use hand gloves.
- In case of seed broadcasting, do not sow seeds against the wind direction.
- Clean and wash the machine and nozzle thoroughly before herbicide application.
- Use protective clothing, hand gloves, face mask and cover over head with cap during herbicide application.
- Do not eat, smoke at the time of transplanting and weeding.
- Keep herbicide away from the reach of children.
- During harvesting ensure that the operators should wear tight clothing and secure their hair to avoid entanglement.
- Never clean, maintain, adjust or clear jams when the harvester is on.
- Stay clear of discharges, outlets, and all moving parts of the harvester.
- Make sure all guards like belt guards, pully guards etc. are in place in harvester.
- Always read the operators manual of your machine and make yourself familiar with the safety risks.
- If equipment breaks down make sure that it is properly repaired before it is used again. Improvisation is dangerous and might lead to failure of parts.

WHAT YOU HAVE LEARNT

Let us recapitulate and enlist salient points we have learnt through this lesson:

- The traces pesticides leave in treated product are called residues.
- The amount of residue of the toxicant that can be permitted to be present in / on the produce used by man and his animals is called tolerance limits. It is expressed in ppm.

Notes

- As pesticide application is a major activity in the use of agrochemicals and also the most hazardous, precautions to be taken before, during and after application are treated separately.
- As a First Aid to pesticide poisoning, remove poison from the patient's stomach immediately by inducing vomiting.
- Safety me

TERMINAL EXERCISE

1. Describe harmful effects of agrochemicals.
2. Explain safety measures during chemical application.
3. What are the First Aid treatments for agrochemical poisoning?
4. Explain the symptoms of insecticidal poisoning.
5. Explain the antidotes used against insecticidal poisoning.

ANSWERS TO INTEXT QUESTIONS

13.1

1. Maximum Residue Level
2. neuro (brain)
3. locust
4. 2.5
5. evening

13.2

1. Induce vomiting
2. Vitamin K
3. Dimercaprol (BAL)
4. severe
5. gastric levage

Notes

14

MARKETING AND ENTREPRENEURIAL SKILLS

The traditional channels of marketing from time immemorial have been dominating the marketing of agricultural produce in India. There are primarily several links in this chain. The chain starts with a farmer and ends at the ultimate consumer. At each stage there are numerous players. Due to the involvement of a large number of players in the supply chain there are chances of adulteration at each level of procurement and processing of paddy. Now the government of India is launching e- mandi for the farmers. The rates and other details will be furnished on the electronic platform. It will provide a dual benefit to producers by averting the need to bring produce to the market physically and enabling them to avail funding against the commodities stored in the warehouses, thus strengthening the price risk management framework for the farmer. Farmers and any other person can export the produce and earn more money.

OBJECTIVES

After reading this lesson, you will be able to:

- explain the traditional marketing system;
- discuss the modern marketing system – e mandi;
- explain supply chain of rice;
- develop skills to become a rice exporter.

14.1 MARKETING SYSTEM

14.1.1 Traditional Marketing System

Rice is produced under the traditional farming method and goes into the supply chain through the market yards (mandies) established under the Agriculture Produce Marketing

Notes

Act and orders of various State Governments. The produce is brought to designated market yards and sold by open auction, enabling the farmers to get the best price.

In the *mandi* system, farmers get a very low share of the rupee due to a long chain of intermediaries and cartelisation at the physical marketplace, which adds two major costs viz., the intermediaries' margins and multiple handling costs.

The Central Government has taken up the task of total overhaul of the Agricultural Produce Market Committee (APMC) Act to make system more efficient and reduce the number of intermediaries so that the end user is able to pay the best price which goes directly to the farmers.

14.1.2 With Contractual Arrangements

In all agricultural produce, there is no legal framework for contract farming except for mill linked sugarcane production under the Sugarcane Act. Even in the existing legal framework, it is possible to enter into an understanding with the farmers who can be given the necessary financial assistance, inputs and technical know-how by the manufactures, in return for a promise that the final produce will be given to the mill. This is a very efficient system and has been successfully implemented by several companies in India such as Pepsi, Godrej, ITC, etc. The farmer feels obligated to give his produce to the benefactor company and the company gets the produce of desired quality at the best price possible because there are no intermediaries.

14.1.3 National Agriculture Market (e-Mandi)

National Agriculture Market (NAM) is a pan-India electronic trading portal which networks the existing APMC mandies to create a unified national market for agricultural commodities. The NAM Portal provides a single window service for all APMC related information and services. This includes commodity arrivals & prices, buy & sell trade offers, provision to respond to trade offers etc.

Components of NAM

- A national e-market platform for transparent sale transactions and price discovery initially in regulated markets. Willing states to accordingly enact suitable provisions in their APMC Act for promotion of e-trading by their State Agricultural Marketing Board/APMC.
- Liberal licensing of traders / buyers and commission agents by State authorities without any pre-condition of physical presence or possession of shop /premises in the market yard.
- One license for a trader valid across all markets in the State.
- Harmonisation of quality standards of agricultural produce and provision for assaying (quality testing) infrastructure in every market to enable informed bidding by buyers. Common tradable parameters have so far been developed for 25 commodities.

Notes

- Single point levy of market fees, i.e on the first wholesale purchase from the farmer.
- Provision of Soil Testing Laboratories in/ or near the selected mandi to facilitate visiting farmers to access this facility in the mandi itself.
- M/s. Nagarjuna Fertilizers and Chemicals Ltd. is the Strategic Partner (SP) who is responsible for development, operation and maintenance of the platform. The broad role of the Strategic Partner is comprehensive and includes writing of the software, customizing it to meet the specific requirements of the mandies in the States willing to integrate with NAM and running the platform.

Benefits of NAM

NAM provides a number of benefits to various stakeholders of the system.

- For farmers, NAM promises more options for selling their produce and competitive returns.
- For local traders, NAM will provide access to larger national market for secondary trading.
- For bulk buyers, processers, exporters, NAM will enable direct participation in the local mandi trade, reducing intermediation cost.
- Stable prices and availability to consumer.
- For mandis, NAM benefits in terms of reduction in book keeping and reporting system, which are generated automatically; better monitoring and regulation of traders and commission agents; completely transparent system which eliminates any scope of intentional/un-intentional manipulation of tendering / auctioning process.
- Improvement in the market fee collection by means of accounting all the transactions that are taking place in the market; reduction in manpower requirements as tendering / auctioning process takes place through the system; analysis and forecasting of the arrivals and prices; availability of the activities of each APMC on the website directly.

14.2 SUPPLY CHAIN OF RICE

In the process of paddy movement from farm gate to final processing unit the ownership changes from **FARM** to **KACCHA ARHTIYA - PAKKA ARHTIYA – TRADER** and finally to the mill increasing the paddy price without value addition. To bring down the cost of post harvest handling and bringing more flexibility in the organizational structure the need of the hour is to develop warehousing facilities to cater to the need of the farmers.

The current supply chain for basmati rice from the stage of cultivation to domestic sale/ export is based on the traditional model, as represented below:

Notes

Current Chain for Exporter of Basmati Rice

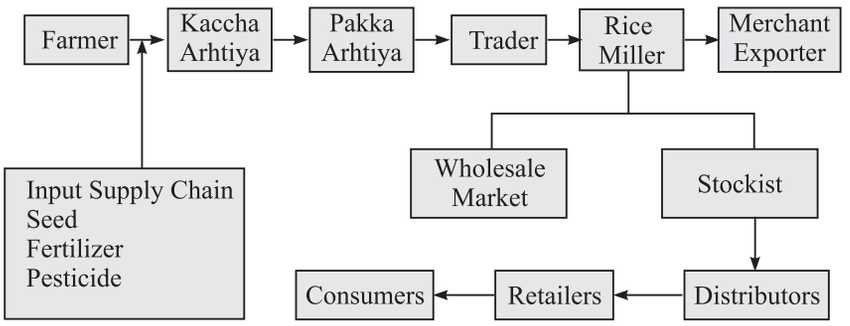


Fig. 14.1: Supply chain of basmati rice

The primary operational activities of each of the above-identified stakeholders are as follows:

14.2.1 Farmer

(a) Purchase of the paddy seeds & other farm inputs from the local market.

(b) Planting of the seeds in the nursery and, subsequently, transplanting the same to the rice fields.

(c) Protecting the crop from biotic & abiotic stresses.

(d) Harvesting of the crop on maturity and, thereafter, threshing, drying and cleaning of the produce.

(e) Sale of produce at the grain market.

14.2.2 Kaccha Arhtiya

(a) Kaccha arhtiya provides loan to the farmer for the various farming activities and day-to-day needs.

(b) Facilitating the selling of the farmer's produce at the local grain market at competitive rates.

(c) Issuance of the J-Form (B1) to the farmer against sale of his produce.

(d) Issuance of the J-Form (B2) to the Pakka Arhtiya.

(e) Recovery of the loan amount from the farmer after the sale of the farmer's produce.

(f) Providing farm inputs such as seeds, fertilizers, insecticides & pesticides etc. to the farmers.

14.2.3 Pakka Arhtiya

(a) Purchase of the farmer's produce through the Kaccha arhtiya.

(b) Paying the Dammi (commission) & other expenses to Kaccha arhtiya against the purchases.

Notes

(c) Collection of the I-Forms from the Kaccha arhtiya.

(d) Selling the produce purchased to the miller/exporter, as well as to the local market.

14.2.4 Traders

(a) Storing of the purchased produce at the warehouse.

(b) Selling of the produce in the local market, as well as to the exporter.

14.2.5 Rice Miller

(a) Visiting the growing areas and identification of the paddy variety grown.

(b) Purchase the produce with approved specification issued by laboratory.

(c) Storing, drying, paddy milling, sorting, grading and packing of rice.

(d) Selling the final product in the domestic and international market.

14.2.6 Wholesaler

(a) Selling of the final product in bulk quantity.

14.3 HOW TO BECOME A RICE EXPORTER?

The export of rice is going on to more than 130 countries of the world. India is exporting basmati and non basmati rice in different countries. The increasing demand of basmati rice, which is grown only in India and Pakistan have more potential. During 2014-15 India earned about 27,900 crore rupees only from basmati rice.

14.3.1 Type of Exporter

1. **Merchant Exporter:** Merchant exporter does not have own manufacturing and processing unit.
2. **Manufacturer:** Procure & process raw material at his/her factory and exports finished products.
3. **Service Provider:** One who export services like health care, consultancy, software, hotels etc.

14.3.2 Issue of Importer Exporter Code (IEC)

Importer Exporter Code is a major step towards ease of doing business. It is PAN based 10 digit code and it is the basic requirement for commercial trade. It can apply both online and offline. Filling of form ANF 2 A with a nominal fee of Rs. 500/- are required to get the IEC. Visit deft.gov.in to apply.

14.3.3 RCMC from APEDA

The Registration-Cum-Membership Certificate (RCMC) is issued to exporters. The issuance of RCMC has been made on line using digital. Mandatory for agricultural produce export and issued from APEDA. Visit apeda.gov.in for more information.

Notes

14.3.4 Data Mining

Data mining is important to know:

- Size of world market of product export.
- Trend of market.
- Who are the competitors?
- What are the tariff barriers?
- Any sanitary/phytosanitary issues.
- To get suitable buyer and country.

14.3.5 Buyer Management

- Most important aspect in international trade.
- Identify buyer and procure order.
- Sign the contract with clear pricing, freight charges, payment terms etc.
- Production and supply management.
- Realization of payment.
- Delivery of goods and follow up.

14.3.6 INCO Terms

- You have to negotiate a sale contract with buyer before any trade happen.
- There are some Inco terms likes FOB (Free on Board), CIF (Cost insurance & freight) etc.
- INCO terms were published by international chamber of commerce in 1936 and from time to time. They are widely accepted terms in domestic and international trade.
- These terms defines task, responsibility, cost, risk including cost and insurance.
- Inco terms significantly reduces misunderstanding among traders hence minimize the litigation.

14.3.7 Directorate General of Foreign Trade (DGFT)

Directorate General of Foreign Trade (DGFT) is an organization under Ministry of Commerce & Industries. Its first and foremost work is to formulate foreign trade policy and its implementation, training of entrepreneur through "Niryat Bandhu Scheme" and it runs various incentivize schemes for the exporters. It issues Import Export code (IEC).

Notes

14.4 FACTORS AFFECTING PRICES OF BASMATI RICE

There are various factors which affect the price of Basmati Rice. Some of them are as follows:

- **Demand:** There is a demand for basmati rice both for export as well as local consumption. India is the largest producer and exporter of basmati rice with about 2/3rd of the production being exported. As a result of this export orientation, the import demands received by other countries affect the prices of basmati rice.
- **Climatic Conditions:** In India, agriculture is dependent on the monsoons. Even the production of basmati rice to a considerable extent is based on the monsoons. Weather as a whole is a key factor which plays a dominant role in the production as well as productivity of basmati rice.
- **Government Policy:** Government export import policy plays a significant role in determining the price of the rice.
- **Market Conditions:** The overall sentiments and the conditions in the rice market affect basmati price trends.
- **Pattern of Consumption:** The pattern of consumption in domestic market also affects the price of the rice.
- **Economy:** The economic growth and performance of importing countries also affect the price. Other fragrant rice from other countries also has an influence on the market which further influences the price of basmati rice.
- **Cost:** Cost of cultivation & processing.

14.5 ENTERPENURSHIP SKILLS

A paddy farmer needs to know and understand following to become successful:

- Get updated about the latest varieties of paddy by reading the newspapers and magazines
- Keep abreast with the latest knowledge by reading brochures, pamphlets, and product information sheets
- Read relevant newspapers/booklets
- Read the hazards of use and contamination written on the labels of chemicals used in paddy production.
- Maintain effective working relationships
- Communicate clearly and effectively with others like farmers, concerned officer/stakeholders
- Understand available information and grasp its meaning.
- Seek advice from senior people / experts.
- Proper record keeping.

Notes

Thus, as a commercial paddy farmer, you have to

- make decisions pertaining to the concerned area of work;
- monitor and maintain the material and equipment required for different paddy production operations;
- identify problems that may arise in carrying out tasks and take preventative action;
- follow basic arithmetic and algebraic principles;
- plan and organize paddy nursery and field procedures starting from land preparation to harvesting;
- organize meetings / demonstrations with Agricultural Departments whenever necessary;
- participate in paddy exhibition/seminar/workshop;
- attend refresher training;
- attend and make use of exposure visit;
- work with paddy experts;
- apply, analyze, and evaluate the information gathered from observation, experience, reasoning, or communication, as a guide to thought and action;
- take up your own working and learning.

INTEXT QUESTIONS 14.1

1. Who issues the IEC?

   (a) APEDA (b) DGFT

   (c) State Goverment (d) NABARD

2. IEC is based on?

   (a) Adhar card (b) Pan card

   (c) Passport (d) Ration card

3. Inco terms were published in?

   (a) 1936 (b) 1985

   (c) 1956 (d) 2015

4. Registration of company in APEDA is called?

   (a) RCAC (b) CCPP

   (c) MCRC (d) RCMC

WHAT YOU HAVE LEARNT

Notes

Let us recapitulate and enlist salient points we have learnt through this lesson:

- The marketing system of produce is traditional and have to sale in *mandies* on auction base.
- There are many middlemen involved in marketing system and reduce the cash in farmers hand and also deterioration in quality due to handling in different hands.
- National Agriculture *mandi* system is also introducing to secure the farmers rights and rates.
- Supply chain of rice includes farm to kaccha arhtiya to pakka arthiya to trader to rice miller to wholesaler.
- Merchant exporter, manufacturer and service provider are the three types of rice exporter.
- Demand, climatic conditions, government policies, market condition, pattern of consumption, economy and cost influences market price of basmati.
- As a successful commercial paddy farmer you need to be updated and make judicious decisions for different paddy production operations.

TERMINAL EXERCISE

1. How many type of rice exporters are there, describe them?
2. Expand the abbreviations:
   (a) APEDA (b) DGFT
   (c) IEC (d) RCMC
3. Write a short note on e-mandi.
4. What are the major factors affecting the rate of basmati rice?
5. What are the entrepreneurship skills one should have for successful commercial paddy farmer?

ANSWERS TO INTEXT QUESTIONS

14.1

1. (b) DGFT
2. (b) Pan card
3. (a) 1936
4. (d) RCMC

Notes

15

MECHANIZATION IN PADDY

We have already learnt that for raising a paddy crop, several farm operations are to be carried out from seed bed preparation to harvesting, viz. preparatory cultivation practices, seeding, transplanting, weeding, harvesting etc. All these operations require some machines viz plough, harrow, puddler, weeder, transplanter, thresher etc. to enhance efficiency and effectiveness of agricultural operations, which helps in reducing time & labour cost, achieve uniformity and minimal drudgery for making the paddy farming more profitable.

In this lesson we will identify various farm machineries used in paddy cultivation and learn their operation in the field.

OBJECTIVES

After reading this lesson, you will be able to:

- identify farm machineries used in the paddy farming;
- explain the working of machinery;
- demonstrate field operations using relevant machineries.

15.1 FARM IMPLEMENTS AND MACHINERY USED FOR LAND PREPARATION

For land preparation, preparatory cultivation practices like ploughing, harrowing and planking are required for getting a fine seed bed which can provide intimate soil-seed contact as against relatively coarser seed bed to facilitate better germination of seed. Following are the implements required for the same:

A. Plough

The plough is widely used implement with modifications and alterations. Tractor mounted mould board plough its used for land preparation for paddy crop.

Tractor Mounted Mouldboard Plough

A mouldboard plough is an implement which opens, inverts and pulverizes the soil (Fig. 15.1). It cuts, and inverts the soil, unlike the *desi* plough, which only cuts but does not invert it. It cuts a rectangular section of the soil, thus does not leave uncut space. It is used to uproot heavy weed growth, stumps of the previous crop and turning of the green manure crops. The roots of the uprooted weeds are exposed to the sun and are killed. It is used to mix farm yard manure with the soil thoroughly.

Fig. 15.1: Mouldboard plough

B. Harrow

A harrow is an implement for breaking up clods and smoothing out the surface of the soil. It is distinct in its effect from the plough and is used for deeper tillage. Harrowing is often carried out on fields to follow the rough finish left by ploughing operations. Few uses of harrow are as follows:

- To break the crust formed after a shower.
- To collect the weeds from the fields.
- To prepare the seedbed.

Some harrows commonly used in the country are:

(i) Blade harrow

It is the commonest hoeing implement used in rain fed areas of lighter soils. It differs from other harrows having a horizontal blade instead of tines. Blades are replaceable and on becoming blunt can be sharpened. The blade moves in the upper surface of the soil without invert it and forms a slightly disturbed layer at the top of the soil. The weeds are also cut below the surface of the soil. They remain on the surface, as such and serve as organic mulch. The weeds having deep roots and underground bulbs are not eradicated by it. Therefore, these should be uprooted with a *kasaula* before the blade harrow is used.

(ii) Disc harrow

It is provided with concave discs varying in number (Fig. 15.2). They are 40-60 cm in diameter and are fixed on a square axle at 15- 25 cm. The disc harrows have one or more

Notes

sets of discs. Bullock-drawn disc harrows are also being used. The disc harrow is very effective in cutting and pulverizing the soil. Disc-harrows are used to prepare the seedbed besides destroying the weeds. Offset disc-harrows are particularly used for the first tillage after harvesting a crop.

Fig. 15.2: Disc harrow

(iii) Rotavator

Rotavator is suitable for preparation of seed bed in the single pass both in dry and wetland conditions. It kills weeds and incorporates straw in the field.

Fig. 15.3: Rotavator

C. Planker

Planker is an important implement made of a wooden plank or iron of varying lengths. Following are the uses of planker:

- It makes soil surface compact and conserve soil moisture.
- A planker is used to cover seed after sowing.
- It is also used to break the colds, but not so efficiently as a roller, because its weight is spread over large area.

Notes

- It also levels the soil to some extent.
- It also works to some extent as a scraper when an iron plate is fitted on its front side along with its length.

Types of plankers

(i) Bullock drawn planker

It is made up of a thick plank of wood of different length according to requirement. The wooden pegs are fitted with iron nails on the upper side towards the ends of the plank for hitching. These pegs can be replaced by iron rings. A great deal of care is taken to ensure that the lower surface of the planker is very smooth. It helps to compress the soil evenly and does not drag the soil unnecessarily in front of it.

(ii) Tractor –drawn planker

This planker is made up of very heavy wooden plank of 4.5 metres long, 25 cm thick and 40 cm wide, with two iron rings at the ends. It facilitates the breaking of clods, but it cannot be used after sowing to cover the seed, as it gathers a larger quantity of soil in front.

D. Rollers

Uses

- Roller is used to crush and grind the clods and compress the soil.
- It is particularly used in heavy soils. Because it is heavier and the weight per unit area is more than that of planker.
- It is also used on grassy grounds for compressing them.

Types of roller

(i) The Wooden Roller

It is made of a cylindrical log, about 2.7 meters in length and 60 cm in diameter. Two iron rods, thickened at the outer ends are inserted at the two ends into the centre just to serve as an axle. The axle is provided with iron hoops at the rods for bitching. It is drawn by one pair of bullock.

(ii) Iron Roller

It is composed of number of cast-iron rings about 60 cm in diameter. The rings are mounted on a common axle to make a roller of the desirable length. The length can be increased or decreased by adding or reducing the number of iron rings. A hoped frame of iron is provided for hitching. Sometimes, a seat is provided for the worker to sit on.

(iii) Stone Roller

Some stone rollers are also in use in some parts of the country for threshing grain. They are almost cylindrical with some buldge at centre. This facilitates the working of the roller

Notes

in small circles while threshing grain. The length of the roller is 76 cm. And the diameter is 45 cm. usually. The construction is similar to that of the wooden roller.

E. Leveller

Levelling is an essential operation in farming to ensure uniform irrigation. Levelling of the fields is done with levellers which can collect loose soil from high spots and put it into low-lying ones. They are of particular use when new land is brought under cultivation.

(i) Leveller drawn by bullocks

It consists of a wooden plank, 2.7 metres in length and 40 cm in width. An iron plate of 13 cm in width and sharpened at its lower end, is fixed with nails at the lower end of the wooden plank to serve as scraper. The iron scraper is provided with two iron rings towards the ends, about 12 cm from the lower end for hitching. The handle is meant to control the leveller, and pressure is also put on it when it is in position to collect the soil (Fig.15.4).

Fig. 15.4: Leveller drawn by two pairs of bullocks

(ii) Leveller drawn by a tractor

It is made of thick iron plates and is bigger than that drawn by bullocks. There is a provision for hitching to the tractor (Fig.15.5).

Fig. 15.5: Tractor drawn leveller

Notes

iii) Laser land Leveller

The main components of laser land leveller are Drag Scrapper/bucket, Laser transmitter, Laser receiver, Control box, Hydraulic system. It can level the field at desired slop.

Fig. 15.6: Laser land leveller

INTEXT QUESTIONS 15.1

1. ..... plough is used to open, invert & pulverise the soil.
2. ..... is used for deeper tillage.
3. ..... is the commonest hoeing implement used in raifed areas of lighter soils.
4. ..... are used in heavy soils to crush & grind clods and compress the soil.
5. Levelling is essential operation in farming to ensure .....

15.2 IMPLIMENTS USED FOR PUDDLING

Puddling is the most important operation in the preparation of soil bed for transplanting rice. Puddling helps in making soil impervious which assists in reducing the deep percolation losses of water. Prerequisite for puddling is preparatory dry tillage. The indigenous plough is the most prevalent implement used as a puddler in spite of its poor efficiency. There are several animal drawn and power operated puddlers developed in India. Among the power operated puddlers, power tillers and tractors are popular.

Power drawn tiller

It is a 12 HP self propelled machine specifically useful for paddy fields as it can take short turns (Fig. 15.7). It comes with a package of implements like rotavator for puddling and cultivator for land preparation. It can be used for operations like pumping, threshing and for farm transport. It takes about 5 hours to puddle one hectare.

Fig. 15.7: Power tiller

A.P.A.U. Puddler

It is a bullock drawn implement. With the movement of the bullocks, the shaft rotates the blades, which in turn churn the soil. It is suitable for all types of soils. It is advisable to puddle the soil twice or thrice. The implement set up has provision for seat for the operator.

Cono puddler

The puddler utilizes a new concept of conical shaped rotors for puddling in soft paddy soil. It operates in the soil in a horizontal back and forth movement. It can be operated in all types of soils since this is a lightweight and modular implement (Fig. 15.8).

Fig. 15.8: Cono puddler

15.3 IMPLEMENTS FOR SEEDING AND PLANTING

A. Seed Drills

Amongst the various methods of direct seeded rice, viz. Broadcasting, drilling and hill dropping, the drilling of seed has its own merits. The seed is dropped at a uniform and

required depth, ensuring uniform germination. The drilling of paddy seed can be done with the help of different types of seed drills.

(i) Power tiller mounted zero till drill machine

The power tiller mounted zero till drill consists of five inverted Tee type furrow openers, seed and fertiliser hoppers and fluted roller type metering mechanism (Fig. 15.8). A compaction roller is provided for closing the slit created by furrow openers after the placement of seed and fertilisers. It is mounted on the hitch point of 8-10 hp power tiller. It can directly drill seed and fertilizer without seedbed preparation. It is suitable for wheat, barley, lentil, chickpea, pea and paddy. Field capacity of the machine is 0.15 ha/h and field efficiency is 65%.

Fig. 15.9: Power tiller mounted zero till drill machine

(ii) Tractor-drawn seed cum fertilizer drill

It drills fertilizer and seeds together but delivers them separately in a single drive at different depths thus improves germination. It consists separate containers for seed and fertilizer (Fig. 15.10).

Fig. 15.10: Tractor drawn seed drill

B. Paddy Drum Seeder

A row seeder (also known as drum seeder) used for direct sowing of the pre- germinated paddy seeds in the rows at spacing of 20 cm in puddle soil. It uses very less amount of seed

per hactare (15-16 kg) as compared to transplanting and less labour. There is saving in the cost of cultivation to the tune of 35 per cent by using this device (Fig. 15.11). The advantages of the machine are

- Lightness of the machine
- Ease of operation with one operator,
- Ease of fabrication at any local workshop
- Low cost

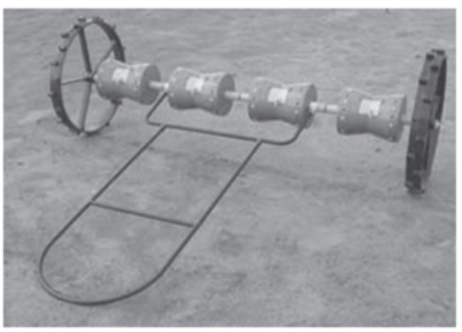


Fig. 15.11: Paddy drum seeder

C. Paddy Transplanter

It is a mechanized rice transplanter (Fig. 15.12). The machine transplants at a row spacing of 23 cm with a provision to adjust the plant to plant distance, depth of planting and number of plants per hill. It requires mat type nursery. This is a high labour saving machine, eliminates drudgery, increases productivity and gives very high return. The machine can cover about 0.8 ha in a day with a net saving in labor of about 40 per cent.

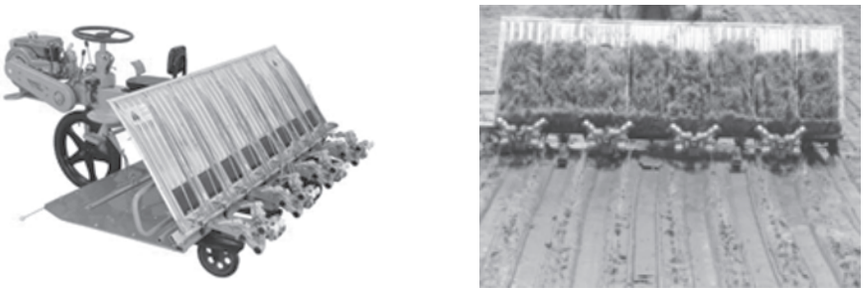


Fig. 15.12: Paddy transplanter

15.4 WEEDING EQUIPMENTS

Weeds are serious menace to crops as they reduce the yields and farmers income as they affect crop growth and development in many ways. Instead of weeding manually and throwing the weeds outside the plot there are several advantages of turning the weeds into the soil by using an implements.

Notes

A. Animal drawn tool frame for weeding

It is an attachment to multipurpose animal drawn tool frame (Fig.15.13). Sweep type tynes are mounted on a steerable tool bar behind the tool frame. It is suitable for interculture and weeding operations in row crops. This attachment was developed at CIAE, Bhopal during 1982-85. It saves 90 per cent labour and operating time and 88 per cent cost of operation compared to conventional hand hoe (khurpa). It is suitable for interculture and weeding operations in row crops.

Fig. 15.13: Weeder

B. Japanese paddy weeder

This rotary weeder has two cylindrical rotors mounted fore-and-aft on the frame. The rotors have same radius and width, and their axle is perpendicular to the direction of the weeder and horizontal to the ground. They typically have 6 rows of 3-4 tines welded on the surface (Fig. 15.14). The weeder has to be operated with a back and forth movement on the line in order to be effective in SRI fields, because its width is around 15 cm, narrower than the 25 cm space. The farmers need to move in such a way in order to cover the full width of operation in the line; conversely constantly pushing towards one direction would force them to do a second passage in the same line.

Fig. 15.14: Japanese paddy weeder

C. Cono weeder

The cono weeder is a machine first developed by the International Rice Research Institute (IRRI). It is of Rotary type with two conical rotating drums, single shafted. They are furnished with alternating ranks of straight-edged and serrated blades, which are designed to churn the top 3 cm of the soil. Each cone is mounted on an arm inclined downward

towards the soil, so that the lower edge of each cone is flat to the soil surface and the blades engage the soil horizontally. When a bladed cone is rolled along a straight path on the soil surface, the blades displace the soil differentially at points along the axis of the curve, creating a more aggressive tillage action (Fig. 15.15).

Fig. 15.15: Cono Weeder

INTEXT QUESTIONS 15.2

1. ..... is a light weight and modular puddler.
2. ..... can drill seeds and fertilizers directly without seed bed preparation.
3. ..... delivers seeds and fertilizers separetly.
4. A ..... is used for direct sowing of the pre-germinated paddy seeds.
5. Paddy transplanter requires ..... nursery.
6. ..... is preferred over manual weeding.

15.5 HARVESTING EQUIPMENTS

Delayed harvesting due to non availability of labours will lead to yield losses on account of shattering. Various equipments used for harvesting are as follows:

A. Sickles

In the improved sickles the cutting edge is serrated instead of being plain. The serrated edged blades facilitate self sharpening and better quality of cut. The handles are made light with a better grip to improve the operators comfort. These sickles harvest 17% more area in a give time in comparison with traditional sickles.

B. Vertical conveyor reaper

Vertical conveyor reaper (VCR) harvests and windrows the crop to one side. This augurs well with the farmers' practice where the paddy is left in the field for some time for proper drying. It can harvest about half an acre in one hour. The shattering losses are also

minimized. The reaper allows rapid harvesting and subsequent replanting of the next crop within the recommended planting time. It also allows farmers to save labour expenses.

C. Combine Harvester

This is self propelled machine which cuts, conveys, threshes, cleans and bags the produce from the field. It can harvest even a lodged crop. Wheel and chain combines are available. The chain combine is having more manoeuvrability by having lesser turning radius. It has working width of about 4.2 m. The straw disposal and utilization seems to be problematic with the use of combines.

Fig. 15.16: Combiner harvester

15.6 THRESHING EQUIPMENT

Traditionally threshing is done by treading by bullocks or trampling by tractors. It takes more time and loss of yield through unthreshed paddy is more. This has been replaced by power operated threshers of 5 to 15 HP with either diesel or electrical power driven source.

Pedal Operated Thresher

It consists of wire-loop type threshing cylinder operated by foot pedal. It is suitable for threshing rice. It saves 20 percent labour and 40 per cent operating time compared to conventional method of hand beating on a wooden platform.

15.7 OTHER SMALL FARM IMPLEMENTS OR TOOLS

Various types of hand-tools are used by the farmer in a paddy field; some of them are described below:

A. Spade

It consists of an iron blade of 30 × 30 cm^2. One end of it is sharpened and the other is provided with a peen into which a 75 cm. long, wooden handle, is inserted for gripping.

Notes

It is used for digging, bunds, cleaning water/channels, levelling small plots for sowing a nursery and spreading the heap of farmyard manure in a field.

B. Khurpa

It consists of a small iron blade, 15 cm in width and small wooden curved handle to provide a suitable grip. It is used mainly for hoeing, weeding, uprooting nursery seedlings for transplanting and for grass harvesting.

C. Wheel hoe

It consists of one wheel, one handle with two grips and an iron frame. Two or three triangular shares are fitted with two or three tunes with bolts and nuts and are replaceable. As soon as the shares are worn out, they can be replaced. The worker operates the hoe in a standing position by pushing through a short length at a time. The implement is very useful in light soils.

D. Pharua

A semicircular iron or wooden piece, 30 cm in radius, is provided with a long handle. The worker slightly bends to work with it. It is used for removing dung from the farmyard, for levelling small beds and heaping scattered grain on the threshing floor sometimes, it is used to push or drag the muddy sewage water into water channels to take it to the fields.

E. Sickle (Darati)

It consists of a wooden handle and an iron blade which is curved and serrated on the inner side. It is used for harvesting field crops and fodders, for weeding nurseries etc. The teeth are sharpened when they get worn out owing to working the tool for long period. Its life is about 2-3 years

F. Knapsack sprayer

A knapsack sprayer is suitable for spraying pesticide or herbicides. This sprayer is entirely manual and is carried on an operator's back. The sprayers have a built-in piston or diaphragm pump that is operated by hand. Tanks on the knapsack sprayer typically are made of plastic or steel and hold three to five gallons. Some knapsack sprayers have a mechanical agitator that moves when the pump is used, others have jet agitation. Before spraying, shake the entire sprayer to ensure a uniform mix.

WHAT YOU HAVE LEARNT

- Use of suitable machines for different farm operation is required for effective utilization of inputs.
- Plough, harrow, planker, rollers, leveller, puddler etc are required for preparation of fine tilth for paddy cultivation.

Notes

- Seed drills, paddy drum seeder, paddy transplanter are transplanting equipments.
- Weeders are used to control weeds in standing crop of paddy.
- Sickle, VCR, combine & thresher are used for harvesting & threshing the paddy crop.
- Various small tools like spade, kasaula, khurpa, sickle etc. are used for different activities in paddy cultivation.

TERMINAL EXERCISE

1. Enlist and describe the implements required for land preparation.
2. What are the major implements required for paddy transplanting?
3. Describe the equipments required for paddy harvesting.
4. Write short notes on:

   (a) Rotavator (b) Cono puddler (c) Paddy drum seeder

   (d) Cono weeder (e) Combine harvester
5. List out the small tools required in paddy field.

ANSWERS TO INTEXT QUESTIONS

15.1

1. Mould board plough
2. Harrow
3. Blade harrow
4. Rollers
5. uniform irrigation

15.2

1. Cono
2. Power tiller mounted zero till drill
3. Tractor drawn seed cum fertilizer drill
4. drum seeder
5. mat type
6. Weeder