Paddy Farmer

(Job Role)

Qualification Pack: Ref. Id. *AGR*/Q0101
Sector: Agriculture

Textbook for Class X

विद्यया ऽमृतमश्नुते
एन सी ई आर टी
NCERT

राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

ISBN 978-93-5292-364-9

First Edition
December 2020 Agrahayana1942

PD 5T SU

₹ 85.00

OFFICES OF THE PUBLICATION DIVISION, NCERT

NCERT Campus
Sri Aurobindo Marg
New Delhi 110 016 **Phone : 011-26562708**

108, 100 Feet Road
Hosdakere Halli Extension
Banashankari III Stage
Bengaluru 560 085 **Phone : 080-26725740**

Navjivan Trust Building
P.O. Navjivan
Ahmedabad 380 014 **Phone : 079-27541446**

CWC Campus
Opp. Dhankal Bus Stop
Panihati
Kolkata 700 114 **Phone : 033-25530454**

CWC Complex
Maligaon
Guwahati 781 021 **Phone : 0361-2674869**

Printed on 80 GSM paper with NCERT watermark

Published at the Publication Division by the Secretary, National Council of Educational Research and Training, Sri Aurobindo Marg, New Delhi 110 016, and printed at Pushpak Press Private Limited, B-3/1, Okhla Industrial Area, Phase-II, New Delhi - 110 020

Publication Team

Head, Publication Division	:	*Anup Kumar Rajput*
Chief Editor	:	*Shveta Uppal*
Chief Production Officer	:	*Arun Chitkara*
Chief Business Manager (In charge)	:	*Vipin Dewan*
Production Assistant	:	*Rajesh Pippal*

Cover and Layout

DTP Cell, Publication Division

Foreword

The National Curriculum Framework (NCF)–2005 recommends bringing work and education into the domain of the curricular, infusing it in all areas of learning while giving it an identity of its own at relevant stages. It explains that work transforms knowledge into experience and generates important personal and social values, such as self-reliance, creativity and cooperation. Through work, one learns to find one's place in society. It is an educational activity with an inherent potential for inclusion. Therefore, an experience of involvement in productive work in an educational setting will make one appreciate the worth of social life and what is valued and appreciated in the society. Work involves interaction with material or people (mostly both), thus, creating a deeper comprehension and increased practical knowledge of natural substances and social relationships.

Through work and education, school knowledge can be easily linked to learners' life outside the school. This also makes a departure from the legacy of bookish learning and bridges the gap between the school, home, community and workplace. The NCF–2005 also emphasises on Vocational Education and Training (VET) for all those children, who wish to acquire additional skills and seek livelihood through vocational education after either discontinuing or completing school education. VET is expected to provide a 'preferred and dignified' choice rather than a terminal or last resort option.

As a follow-up of this, NCERT has attempted to infuse work across subject areas and contributed in the development of the National Skill Qualification Framework (NSQF) for the country, which was notified on 27 December 2013. It is a quality assurance framework that organises all qualifications according to the levels of knowledge, skills and attitude. These levels, graded from one to ten, are defined in terms of learning outcomes, which the learners must possess regardless of whether they are obtained through formal, non-formal or informal learning. The NSQF sets common principles and guidelines for a nationally

recognised qualification system, covering schools, vocational education and training institutions, technical education institutions, colleges, and universities.

It is under this backdrop that Pandit Sunderlal Sharma Central Institute of Vocational Education (PSSCIVE), Bhopal, a constituent of NCERT, has developed learning outcomes based modular curricula for vocational subjects from Classes IX to XII. This has been developed under the Centrally Sponsored Scheme of Vocationalisation of Secondary and Higher Secondary Education of the Ministry of Education, erstwhile Ministry of Human Resource Development.

This textbook has been developed as per the learning outcomes based curriculum, keeping in view the National Occupational Standards (NOSs) for the job role and to promote experiential learning related to the vocation. This will enable the students to acquire necessary skills, knowledge and attitude.

I acknowledge the contribution of the development team, reviewers and all institutions and organisations, which have supported in the development of this textbook. NCERT welcomes suggestions from students, teachers and parents, which would help us to further improve the quality of the material in subsequent editions.

Hrushikesh Senapaty
Director
National Council of Educational
Research and Training

New Delhi
September 2020

About the Textbook

Agriculture is an important part of India's economy, which accounts for about 18 per cent of the GDP and occupies almost 51 per cent of the country's geographical area. The Agriculture Industry employs about 61.5 per cent of the total rural population — both in the organised, as well as, unorganised sector. The requirement for skilled workforce in this industry is increasing rapidly. Skilled workforce under various job roles, such as Paddy Farmer, Solanaceous Crop Cultivator, Tuber Crop Cultivator, Floriculturist — Open Cultivation, Floriculturist — Protected Cultivation, Microirrigation Technician, etc., are in high demand by many States.

The job role of a Paddy Farmer relates to the cultivation of paddy crop as per practices recommended for a particular agro-climatic zone, type of soil, rainfall pattern and climatic conditions to achieve the desired yield. This textbook for the job role of a Paddy Farmer has been designed to impart knowledge and skills to students through hands-on learning experience, which forms part of experiential learning. It focuses on the learning process of an individual. Therefore, the learning activities are student-centred rather than teacher-centred.

The textbook has been developed with the contribution of subject and industry experts, vocational teachers and academicians. Care has been taken to align the content of the textbook with the National Occupational Standards (NOSs) for the job role so that the students acquire necessary knowledge and skills as per the performance criteria mentioned in the respective NOSs of the Qualification Pack (QP). The textbook has been reviewed by experts so as to ensure that the content is not only aligned with the NOSs but is also of quality. The NOSs for the job role of a Paddy Farmer covered through this textbook are as follows.

- AGR/N0104 : Weed management in paddy
- AGR/N0105 : Integrated insect–pest and disease management in paddy
- AGR/N0107 : Harvesting and post–harvest management in paddy
- AGR/N9903 : Maintaining health and safety standards at the workplace

Unit 1 of the textbook discusses weed management practices followed in paddy crop cultivation. Unit 2 focuses on integrated insect–pest and disease management in paddy crop. Unit 3 deals with straw management in paddy, chemical composition of paddy straw and various methods of paddy straw management, whereas, Unit 4 throws an insight into harvesting and storage of the crop. Unit 5 covers paddy marketing. Unit 6 deals with handling emergency situations during crop production. Unit 7 discusses maintaining health and safety standards at the workplace.

We hope this textbook serves as a useful material for students, who opt for this job role, and teachers as well. Suggestions for improving this textbook are welcome.

Rajiv Kumar Pathak
Professor
Department of Agriculture
and Animal Husbandry
PSSCIVE, Bhopal

Textbook Development Team

Members

Anand Kumar Vishwakarma, *Principal Scientist*, ICAR — Indian Institute of Soil Science, Nabibag, Bhopal, Madhya Pradesh

Pundlik Maroti Nimje, Former *Principal Scientist*, ICAR — Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh

Ram Swaroop Meena, *Assistant Professor*, Department of Agronomy, Institute of Agriculture Science, Banaras Hindu University, Varanasi, Uttar Pradesh

R. H. Wanjari, *Senior Scientist*, ICAR — Indian Institute of Soil Science, Nabibag, Bhopal, Madhya Pradesh

Rajeew Kumar, *Assistant Professor*, Department of Agronomy, College of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand

Sanjay Kumar Dwivedi, *Scientist*, Department of Agronomy, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh

Satish Chandra, Former *Additional Director General*, ICAR, Mayur Vihar Phase–1, New Delhi

Member-coordinator

Rajiv Kumar Pathak, *Professor*, Department of Agriculture and Animal Husbandry, PSSCIVE, Bhopal, Madhya Pradesh

ACKNOWLEDGEMENTS

The Council expresses its gratitude to all members of the Project Approval Board (PAB) and officials of the Ministry of Education, erstwhile Ministry of Human Resource Devlopment, Government of India, for their cooperation in the development of learning outcomes-based curricula and courseware for various job roles in different sectors.

We are also thankful to officials in the National Skill Development Agency, National Skill Development Corporation, and Ministry of Skill Development and Entrepreneurship for their support.

Rajesh P. Khambayat, *Joint Director*, PSSCIVE, Bhopal, is appreciated for providing constant support and encouragement during the development of this textbook.

The contributions of our colleagues at the Department of Curriculum Studies (DCS), NCERT, and members of the textbook review team — Saroj Yadav, *Professor* and *Dean* (Academic), NCERT, and Ranjana Arora, *Professor* and *Head*, DCS, are duly acknowledged. Thanks are also due to Sunita Farkya, *Professor,* and Pushp Lata Verma, *Assistant Professor,* at the Department of Education in Science and Mathematics, NCERT; Dinesh Kumar, *Principal Scientist*, and Seema Sepat, *Scientist,* at the Department of Agronomy, Indian Agricultural Research Institute (IARI), PUSA, New Delhi, for reviewing the textbook and giving valuable feedback. Prabhat Tripathi, *Principal Scientist,* and R. Elanchezhian, *Principal Scientist*, ICAR—Indian Institute of Soil Science, Bhopal, Madhya Pradesh, are also acknowledged for reviewing the textbook.

The images used in the textbook have been selected with care and diligence for a clearer understanding of learners. Care has been taken not to violate any copyright issue. The images are meant for educational purpose only and are being provided for the use of the students and teachers. Dinesh Kumar, *Principal Scientist*, Department of Agronomy, IARI, PUSA, New Delhi; Vijay Yadav, *Senior Rice Breeder*, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh; and Narendra Lakpale, *Professor*, Plant Pathology, Indira Gandhi Agricultural University, Raipur, Chhattisgarh, are thanked for providing photographs that have been included in the textbook. Apart from these, the other images used in the book have been sourced from Creative Commons License.

Gratitude is also due to the Publication Division (PD), NCERT, for transforming the manuscript into an attractive textbook. Pawan Kumar Barriar, *DTP Operator* (PD) and Rajshree Saini, *DTP Operator* (Contractual), are acknowledged for flawless layout and design. Sweta Jha, Freelance *Content Editor*, is appreciated for copyediting and finalising the textbook.

Contents

Unit 1

Weed Management in Paddy Crop

Introduction

Other unnecessary plants can, generally, be seen growing along with crop plants in a paddy field. These other plants, which have not been sown, are 'weeds'. They are wild in nature. Weeds grow on their own because their seeds are already present in the field or could have got mixed with paddy crop seeds or transplanting material.

Weeds compete with crop plants for space, nutrients, water and sunlight. Besides, they interfere with the field operations, harbour insects–pests, cause an increase labour costs, degrade the quality of the produce and reduce the yield. An estimated total loss in paddy yield by weeds is about 37 per cent, insects 29 per cent, diseases 22 per cent and animals 12 per cent*.

Checking weed population in a paddy field is of utmost importance. It implies that pure quality seeds must be used and the field must be prepared in such a manner that there is least chance of weed seeds creeping in before sowing of the main crop. Then, comes control, wherein, weeds and other undesirable plants are removed from the field by manual, mechanical, biological or chemical methods.

*__Source:__ *Dhan ki Vaigyanik Kheti* (2016), Indian Council of Agricultural Research, Pusa, New Delhi

Weeds

These are undesirable wild plants, especially, growing among crop or garden plants. They compete with the main plant for nutrients, water, sunlight and space.

Characteristics of weeds

They are the earliest intruders in farmlands, and agricultural fields are virtually never free of them. Some of the prominent characteristics of weeds are as follows.

- Weeds can grow anywhere and in adverse weather conditions.
- Weeds exhibit the ability to germinate faster than the main crop.
- Many of them can multiply through both seeds and vegetative parts.
- Generally, weeds mature early and spread their seeds well before the harvest of the main crop.
- Weed seeds can survive for a longer period.

Fig. 1.1: Shama or jungle rice (Echinochloa colona)

Fig. 1.2: Marvel grass (Dichanthium annulatum)

Session 1: Common Weeds in a Paddy Field and their Effects on Paddy Cultivation

Common weeds in paddy field

Grasses

The leaves of grasses are long and narrow with parallel veins. Their leaves emerge in alternate patterns between internodes. The root system of grasses is fibrous. Grasses are, generally, the most difficult weeds to control in a rice crop field, especially, during early crop stage (Fig. 1.1 to 1.5).

Fig. 1.3: Swollen finger grass or peacock plume grass (Chloris barbata)

Fig. 1.4: Kutki or blue panic grass (Panicum spp.)

Fig. 1.5: Doob or bermuda grass (Cynodon dactylon)

Sedges

These are similar to grasses. But they have triangular solid stems and closed leaf sheaths. They are semi-aquatic plants, which require moist or flooded soils, and are the most common problem in rice fields (Fig. 1.6 and 1.7).

Broad-leaved weeds

These are plants with netted veins across the leaf lamina. They can further be distinguished by their roots, which have taproot system (Fig. 1.8 to 1.20).

Fig. 1.6: Jungli mehendi or blistering ammannia or dadmari (Ammania baccifera)

Fig. 1.7: Gokhula kanta or gokshura (Asteracantha longifolia)

Fig. 1.8: Nanka or oval leaf pond weed (Monochoria vaginalis)

Fig. 1.9: Indian water navelwort or brahmi (Centella asiatica)

Fig. 1.10: Kankawa or Bengal day flower (Commelina benghalensis)

Fig. 1.11: Kana or creeping cradle plant (Cynotis axillaris)

Fig. 1.12: Caupatiya or sunsuniya or water clover (Marselia quadrifolia)

Fig. 1.13: Bhringaraj or false daisy or karisalankanni (Eclipta prostrata)

Fig. 1.14: Bhui aonla (Phyllanthes niruri)

Fig. 1.15: Bukkan (Phyla nodiflora)

Fig. 1.16: Dudhi (Sonchus olaraceus)

Fig. 1.17: Jalmukhi (Rotala densiflora)

Fig. 1.18: Gul mundi (Sphaeranthus indicus)

Fig. 1.19: Motha (Cyperus difformis)

Fig. 1.20: Bara nagar motha (Cyperus rotundus)

Classification of weeds

Based on life cycle

Some weeds complete their life cycle in one season or year, some in two seasons or years and some take longer. Thus, on the basis of life cycle, weeds are grouped into three categories, which are discussed as follows.

Annuals

These weeds complete their life cycle within a season or year and, generally, propagate through seeds, which are produced in large numbers. These may be summer or rainy season weeds.

Biennials

These weeds complete their life cycle in two seasons or years. They complete their vegetative phase in the first season and reproductive phase, i.e., flowering and seed setting, in the second season.

Perennials

These weeds complete their life cycle in more than two years or seasons and may survive indefinitely. They propagate by seeds or vegetative parts, such as rhizome, stolons, bulbs, tubers, stem, roots, suckers, etc.

Based on cotyledons

On the basis of cotyledons, weeds may be classified into monocots or dicots. This classification is important while selecting the type of chemicals for controling weed population.

Monocot weeds

Weed species having single cotyledon are called monocot weeds. These may include grasses, sedges, etc.

Dicot weeds

Weed species having two cotyledons or seed leaves are called dicot weeds. They are also referred to as broad-leaved weeds.

Effects of weeds on paddy cultivation

- Weeds compete with the main crop for space, sunlight, water and nutrients. They suppress the growth of the main crop, adversely affect the quality of the crop and reduce the yield, thereby, causing reduction in the market price of the crop.
- Weeds act as alternate host to insects and pests during off-cropping season.
- The presence of weeds in a paddy field increases the cost of crop production through tillage operations and weed control measures.
- Weeds reduce the yield in different rice varieties by up to the following percentages.

Upland direct seeded rice:	35–45 per cent reduction in yield
Direct seeded on puddle land:	20–25 per cent reduction in yield
Transplanted rice:	10–15 per cent reduction in yield

Crop–weed competition

Crop–weed competition does not kill the crop or weeds. Its major impact is by the way of reduced yield. The extent of crop–weed competition depends on the following major factors.

Planting density

High crop plant density provides less opportunity to weeds for competition.

Growth stage of crop

Early growth stage of crop at the time of weed infestation results in reduced yield as compared to the later stage.

Weed density

More number of weed plants per unit area causes more losses to the main crop.

Rice varieties and their growth pattern

Rice varieties, which have an early and faster growth rate, are less prone to weed competition.

Critical phase of weed competition

The critical period of weed competition is 15–45 days from transplanting in lowland transplanted rice and throughout the growth period in upland rice. Weeding during this period produces almost similar yield compared to that obtained under weed-free conditions. Weed management during this phase gives maximum economic returns.

Practical Exercise

Activity

Visit a nearby paddy field and identify the weeds found there. Paste the samples of the weeds that you have identified in a herbarium file and label them.

Material required: writing material, herbarium file and weed samples

Procedure

- Visit a nearby paddy field and identify the weeds found there.
- Collect the weed samples.
- Paste the samples in a herbarium file and label them, mentioning the botanical names of the weeds. Also, write measures to control the spread of such weeds.
- Present it before the class.

Check Your Progress

A. Fill in the Blanks

1. An undesirable plant, which grows in the main field is called _____.
2. Weeds can multiply through _____ and _____ parts.
3. The stage of crop, which causes maximum crop loss by weeds, is termed _____ period.

4. Weed competition causes reduction in the crop yield by 35–45 per cent in _____ rice.
5. Weeds completing their life cycle within a season or year are known as _____.

B. Multiple Choice Questions

1. Weed is _____.
   (a) an unwanted plant
   (b) a desirable plant
   (c) a beneficial plant
   (d) All of the above
2. Weeds surviving for more than two years or seasons are known as _____.
   (a) annuals
   (b) biennials
   (c) perennials
   (d) None of the above
3. Weed plants, which require flooded soils, are known as _____.
   (a) sedges
   (b) grasses
   (c) broad-leaved weeds
   (d) All of the above
4. The critical period of weed competition for lowland transplanted rice is _____ days after transplanting.
   (a) 30–50
   (b) 15–45
   (c) 20–60
   (d) 25–60

C. Subjective Questions

1. Define weeds and list their characteristics.
2. List the common weeds found in a paddy field.
3. Describe the classification of weeds.
4. Differentiate between the following.
   (a) Grassy and broad-leaved weeds
   (b) Annual and perennial weeds

D. Match the Columns

A	B
1. Fibrous root	(a) Less weed competition
2. More yield reduction	(b) Grasses
3. Taproot	(c) Triangular solid stems
4. High crop plant density	(d) Broad-leaved weeds
5. Sedges	(e) Early weed infestation

Session 2: Weed Management

Annual loss in agriculture production is maximum due to weeds, followed by insects–pests and diseases. Weeds can be managed by different methods, such as cultural, mechanical, biological and chemical. Using chemicals should, however, be the last option, keeping in mind the safety of the environment.

Measures to minimise weed infestation

Preventive measures

Checking the occurence and spread of weeds in a paddy field is a preventive method of weed control. One can check the spread of weeds by taking the following measures.

- Taking care while transplanting seedlings
- Removal of weeds along irrigation channels and bunds
- Sowing weed-free seeds
- Using clean implements
- Using decomposed manure(s)
- Using pre–emergence herbicides

Control measures

These include cultural, mechanical, biological and chemical methods of weed control. Each of these methods has its own merits and demerits. Farmers can choose any of these method or a combination of these to control weeds effectively and economically.

Weed control management practices

Cultural methods

These involve various agronomical practices, such as crop rotation, summer ploughing, field sanitation, time of sowing, use of fertiliser, etc., which help prevent and reduce weed population. These prove to be more effective when used in combination.

Crop rotation

Growing different crops in the same field in successive seasons or years helps reduce weed population and checks their occurence.

Sanitation

Field and irrigation channels should be made free of weeds as it will help restrict the multiplication and entry of weeds in a farm.

Summer ploughing

Deep ploughing during summer season exposes underground parts of perennial weeds like rhizomes and tubers to heat. These weeds are killed after being exposed to high temperatures.

Planting density

Dense planting helps suppress the germination and growth of weeds in a field.

Mechanical methods

The basic measure followed to check weed population is ploughing, which is primarily done for land preparation. However, it also helps in uprooting annual weeds and cuts the roots of annual and perennial weeds at the same time. Conoweeder is used for carrying out weeding in standing crop effectively.

Physical methods

These methods include hand pulling, hoeing, tilling, mowing, burning, flooding, smothering, etc.

Biological methods

In this method, a natural enemy of weed plants, i.e., predators, pathogens and parasites are used to control a specific weed population.

Chemical methods

These relate to measures, in which chemicals (herbicides) that kill unwanted plants are used. This is a

time-saving and effective method of weed management. Many chemicals function on the basis of selective preference *viz.*, a chemical would kill a specific weed plant, without affecting the other crop plant.

Advantages of chemical weed control

- Chemical methods of weed control are more economical, and hence, affordable than hand weeding.
- These methods are less time-consuming and easier to carry out.
- These are the most effective methods compared to other methods of weed control.
- These are suitable for closely spaced crops.

Herbicides

Herbicides are chemicals that are poisonous to plants and are used to kill unwanted plants. Different types of herbicide need to be used at different stages of cropping or planting.

Stage of planting and application

Pre–planting: This refers to the application of herbicide(s) crop planting. Non-selective herbicides are sprayed on existing vegetation to kill weeds before planting or sowing of the main crop, for example *paraquat*, *glufosinate*, etc.

Pre–emergence: This involves the application of herbicide(s) after sowing but prior to the emergence of weeds. Application of herbicides is done prior to weed emergence at 1–3 days after sowing and transplanting. Examples are *benthiocarb* @ 1.0–1.5 kg/ha, *butachlor* @ 1.0–1.5 kg/ha, *oxadiazon* @ 0.5–0.75 kg/ha, *oxadiargyl* @ 0.08–0.10 kg/ha, *pyrazosulfuron-ethyl* @ 0.020–0.025 kg/ha, etc.

Post–emergence: This involves the application of herbicide(s) after the emergence of weeds. The herbicides are applied, usually, at 3–4 leaf stage of weed for better efficacy and control. Examples are *metsulfuron methyl* @ 4–8 g/ha, bentazon @ 1.0–1.5 kg/ha, *bispyribac sodium*

@ 0.020–0.025 kg/ha and 2,4–D @ 0.5 kg/ha (used to control broad-leaved weeds), etc.

Precautions during herbicide application

- Always wear personal protective equipment, such as mask, goggles, gloves and protective clothing at the time of herbicide application.
- Always apply herbicides as per the recommended method, rate and crop stage.
- Mixing muddy water with herbicide reduces efficacy. Therefore, a person must always use clean water.
- After use, clean all parts of the sprayer, such as tank, boom and nozzle. It is done for the maintenance of the sprayer.

Practical Exercise

Activity

Demonstrate chemical method of weed control.

Material required: weedicides, sprayer and personal protective equipment like gloves, gumboots, goggles, etc.

Procedure

- Identify different types of weed in a paddy farm.
- Select chemicals used for pre– and post–emerging weeds.
- Prepare a chemical solution for spraying as the per the recommended dosage.
- Follow the recommended safety measures during the application of weedicides.
- Spray weedicides in the paddy field.
- Write the observation(s) noticed in the farm after 10 days in your notebook.
- Present your observations before the class.

Check Your Progress

A. Fill in the Blanks

1. The application of herbicides in a field after seeding or planting is called _____ application.
2. 2, 4–D weedicide is used to control _____ weeds.
3. Chemicals used for controlling weeds are called _____.
4. Weed control by conoweeder is an example of _____ method.

B. Multiple Choice Questions

1. The most effective and time-saving method of managing weeds is _____.
   (a) mechanical method
   (b) biological method
   (c) chemical method
   (d) cultural method
2. The application of herbicides in a field before sowing or planting is termed _____.
   (a) pre–emergence application
   (b) pre–plant application
   (c) pre–sowing application
   (d) None of the above
3. Herbicide used after sowing or planting of the crop is _____.
   (a) *Butachlor*
   (b) *Bentazon*
   (c) *Metsulfuron*
   (d) *Glufosinate*
4. The application of herbicides in a field after the emergence of weeds is called _____.
   (a) post–emergence application
   (b) pre–emergence application
   (c) post–sowing application
   (d) None of the above

C. Subjective Questions

1. Describe cultural methods of weed control in paddy crop.
2. Describe chemical method of weed control in paddy crop.
3. Differentiate between pre– and post–emergence herbicides with examples.

D. Match the Columns

A	B
1. Hand weeding	(a) Cultural method
2. Crop rotation	(b) Biological control
3. Metsulfuron methyl	(c) Physical method
4. Natural enemy	(d) Post–emergence herbicide

Unit 2

Integrated Insect-pest and Disease Management in Paddy Crop

Introduction

Insects–pests and diseases cause a major problem in paddy cultivation. In order to achieve optimum yield, timely and effective control of insects–pests and diseases is essential. Integrated Pest Management (IPM), also known as integrated pest control, is an approach that integrates practices for effective and economic control of insects–pests so as to realise minimal damage to the main crop (in this case, paddy), produce quality grains, and at the same time, protect beneficial insects and micro-environment of the field. IPM integrates different management systems and strategies to achieve effective and economical crop protection output. IPM makes judicious use of resistant germplasm, agrochemicals, and organic and microbial control agents. The main aim of IPM is to minimise crop losses.

Integrated management for insects–pests

Integrated management for insects–pests and diseases involves the following.

- Field sanitation
- Field scouting and light traps

- Avoiding excess fertiliser application
- Sowing of crop at appropriate stage
- Eliminating egg masses by trimming the tips of seedlings before transplanting as infections occur from the nursery stage
- Using resistant varieties
- Using repellents like Neem Seed Kernel Extract (NSKE) as the first step
- Application of pesticides at appropriate time

Methods of insect–pest management

Cultural methods

Cultural methods of insect–pest management, primarily, impact the initial pest load and help reduce the pace of spread of an established insect–pest. Some of these practices are as follows.

Crop rotation

It is a farm operation, in which different crops are grown in the same field in successive seasons or years. Crop rotation with non-host crop will help reduce the occurrence of insects–pests and pathogens in the field.

Summer ploughing

Ploughing operation is, usually, carried out during the summer months. Exposing hidden insects–pests and pupa to direct sunlight results in checking and reducing their population.

Sanitation

Keeping the fields clean, and collection and destruction of infected parts, hiding pupa and insects–pests reduce the occurrence of insect–pest attack.

Time of sowing

Sowing the crop at appropriate time reduces the occurrence of insects–pests as the crop escapes the susceptible stage.

Planting density

Dense planting helps supress the germination and growth of weeds in a field.

Use of fertilisers

High nitrogen application may promote the occurrence of insects–pests, particularly, sucking insects–pests. Use of optimum and balanced nutrients will help reduce insect–pest attack.

Physical and mechanical methods

These measures indiscriminately kill insects–pests hiding or living in the soil or trashes of previous crop. Some of the common physical and mechanical methods followed by farmers are as follows.

- Burning of trash
- Hand picking
- Deep ploughing

Chemical methods

These bring the desired results quickly and are, thus, popular methods of controlling insect–pest infestation. Chemicals can be used to treat seeds and soil. Chemical application is also done on standing crop in the form of foliar sprays. Often, it may be necessary to use different types of insecticide when insects–pests develop resistance against a particular insecticide.

SESSION 1: INSECT–PEST MANAGEMENT IN PADDY

Major insects–pests in a paddy field

In order to adopt suitable management strategy against insects–pests, it is necessary to first identify them, the nature of damage they can cause to the crop and appropriate measures to check their population and spread.

Table 2.1: Major insects–pests in a paddy field

S. No.	Name of the insects–pests	Damaging symptoms	Control measures
1.	**Paddy stem borer** *Scirpophaga incertulas*	• The insect larva makes tunnels in the main shoot, eats up the growing tissue due to which the central shoot is killed, revealing a 'dead heart'. • The panicle is dried, causing 'white ear' to emerge. Upon pulling, the panicle or the affected tiller easily comes out.	As soon as the symptoms appear, apply any one of the following insecticides, taking care to spray directly into the whorl, at the top. • *Fipronil* 5 per cent SC 1000–1500 g/ha, • *Thiamethoxam* 25 per cent WG 100 g/ha, *Chlorpyriphos* 20 per cent EC 1250 ml/ha. • *Triazophos* 40 per cent EC @ 625–1250 ml/ha. • *Phosphamidon* 40 SL 600 ml/ha
2.	**Gall midge** *Orseolia oryzae*	• This small insect (called maggots) at the larval stage feeds at the base of a growing shoot, forming a tube-like gall, resembling an 'onion leaf' or 'silver shoot'. • Serious infestation results in the absence of panicle emergence.	Spray any one of these insecticides. • *Fipronil* 5 per cent SC 1000–1500 g/ha. • *Thiamethoxam* 25 per cent WG 100 g/ha. • *Chlorpyriphos* 20 per cent EC 1250 ml/ha.

Fig. 2.1: Dead heart

Fig. 2.2: White ear

Fig. 2.3: Egg of rice stem borer

Fig. 2.4: Larva of rice stem borer

Fig. 2.5: Adult (moth) of rice stem borer

3.	**Armyworm or swarming caterpillar** *Spodoptera mauritia*	• Larvae cut the seedlings above the ground and eat up all parts of the plant. • Cattle grazed appearance is found in severely infested fields. • The larva feed and move in large numbers from one field to another (Fig. 2.6).	• Spray *Chlorpyriphos* @ 20 per cent EC 1250 ml/ha during late evening.
4.	**Leaf folder or leaf roller** *Cnaphalocrocis mainsails/ Marasmia patnalis*	• Larva remain inside the leaves they feed on them and fold the leaves longitudinally. • The leaves may remain green for some time but later become white, and then, may even dry up. • Under heavy infestation, the paddy field appears like a 'scorched field'.	• Avoid excessive nitrogenous fertilisers. • Spray Neem Seed Kernel Extract (NSKE) @ 5 per cent or *Carbaryl* @ 50 WP 1 Kg/ha as a preventive measure. • As a measure of biological control, use *Trichogramma chilonis* (egg parasitoids) @ 5 cc (1 lakh egg parasitoid)/ha. Release it thrice on 37, 44 and 51 days after transplanting. • If it does not produce the desired result, use *Chlorantraniliprole* @ 0.4 per cent G 10 kg/ha for soil treatment or *Chlorantraniliprole* @ 18.5 per cent @ 200ml/ha, *Flubendamide* 20 per cent SG @ 125ml/ha, *Cartap* 50 per cent SP @ 1000 gm/ha.

Fig. 2.6: White and dried leaves

Fig. 2.7: Pupa of leaf folder or leaf roller

Fig. 2.8: Adult leaf folder or leaf roller

5.	**Green leaf hopper** *Nephotettix virescens*	• Leaves become yellowish, starting from the tip to downwards and cause stunted growth. • It acts as a vector to transmit rice tungro virus disease.	• A nursery must not be located near street lamps. • Spray the following insecticides — *imidachloprid* 17.8 per cent SL 100–140 ml/ha or *buprofezin* 25 SC @ 500 ml/ha or *thiamethoxam* 25 per cent WG 100 g/ha.
6.	**Brown leaf hopper of paddy** *Nilaparvata lugens*	• Nymphs and adults crowd around the base of the rice plant. • They are sucking in nature and cause heavy damage to the plants. Damaged fields exhibit patches of dry, lodged matured plants, looking like a scorched field, which is called 'hopper burn'. • This pest also transmits viruses, *viz.*, rice ragged stunt, paddy grassy stunt and wilted stunt.	• Avoid excess use of nitrogenous fertiliser for paddy crop. • Minimise water stagnation by intermittent draining. • Employ light traps (at night) and yellow paper or pan traps (day time). • First apply repellents like neem oil @ 15 l/ha of 3 per cent formulation. If it is not effective, apply any of the following. ▪ *Chlorpyriphos* @ 20 EC 1250 ml/ha or *Acephate* 75 per cent SP 666–1000 g/ha, or *pymetrozine* 50 per cent WG @ 300 gm/ha ▪ Direct the insecticidal spray towards the base of the paddy plants.

Fig. 2.9: Green leaf hopper

Fig. 2.10: Hopper burn in rice

Fig. 2.11: Nymph of brown plant leaf hopper

Fig. 2.12: Adult of brown plant leaf hopper

7.	**Rice ear head bug or *gundhi* bug** *Leptocorisa acuta*	• It sucks the sap from grains in the milk stage. As a result, the grains become chaffy. • The insects emit a foul smell. So, they are called *gundhi* bugs. • Black spots develop on the grains at the site of feed puncture.	• At infestation, post–flowering ear head stage, spray any of the following twice a day — Neem Seed Kernel Extract 5 per cent @ 25 kg/ha or *Imidacloprid* 17.8 SL @ 0.6 ml/l water or dusting of *Chlorpyrifos* 1.5 per cent D 25–30 kg/ha

Fig. 2.13: Rice ear head bug (gundhi bug)

Rodent management in paddy

Apart from insects–pests, rodents also cause significant crop losses in a paddy field, if not controlled in time. In India, rodents have been estimated to cause 5 to 10 per cent losses in paddy. Rodent droppings and half-eaten grains are typical symptoms of damage caused by them in grain stores.

Managing field rodents

Traps

These are a popular and inexpensive method of rodent control adopted by most farmers in the country.

Smoking of burrows

This operation is used to fill rodent burrows with smoke (Carbon monoxide and Carbon dioxide), which causes suffocation and even death of rodents that damage the crop.

Burrow fumigation

Fumigation by Aluminium phosphide is a widely used and effective measure of rodent control.

Chemical control

Acute rodenticides

Acute rodenticides *viz.*, Zinc phosphide and Barium carbonate act efficiently and effectively in one single dose.

Chronic rodenticides

These are multi dose and slow acting rodenticides, for example, *warfarin*, *bromodiolone, etc.*

Practical Exercise

Activity

Identify the different type of insects–pests found in a paddy field.

Material required: insects–pests specimen, box, insect net, writing material, etc.

Procedure

- Visit a nearby paddy field and collect the specimen of different type of insects–pests found there with the help of an insect net.
- Put each insect–pest specimen in separate tranparent plastic envelopes and seal them.
- Paste the envelopes in a herbarium file and label each insect–pest.
- Note down the nature of damage caused by the insects–pests and suggest the control measures.

Check Your Progress

A. Fill in the Blanks

1. Growing different crops in the same land in successive seasons or years is termed _____.
2. Ploughing operation carried out during summer months is called _____ ploughing.
3. Dead heart or white ear in paddy crop is caused by _____.
4. Paddy insect, which shows 'scorched field' appearance is called _____.

B. Multiple Choice Questions

1. Tungro virus of rice is transmitted by _____.
   (a) stem borer
   (b) leaf roller
   (c) green leaf hopper
   (d) *gundhi* bug
2. The scientific name of paddy stem borer is _____.
   (a) *Cnaphalocrocis mainsails*
   (b) *Scirpophaga incertulas*
   (c) *Nephotettix virescens*
   (d) *Nilaparvata lugens*

3. In India, paddy losses due to rodents is about _____ per cent.
   (a) 1–4
   (b) 5–10
   (c) 11–15
   (d) 16–20
4. *Gundhi* bugs attack rice during the _____ stage.
   (a) germination
   (b) flowering
   (c) milking
   (d) harvesting

C. Subjective Questions

1. Define Integrated Pest Management. Also, give examples for the same.
2. Describe in brief various methods of insect–pest management.
3. Write some rodent control measures followed in a paddy field.
4. Discuss cultural and chemical methods of insect–pest control adopted in a paddy field.

D. Match the Columns

A	B
1. *Gundhi* bug	(a) Stem borer
2. White ear head	(b) Foul odour
3. Silver shoot	(c) Brown plant hopper
4. Zinc phosphide	(d) Gall midge
5. Stunt virus	(e) Rodent control

SESSION 2: DISEASE MANAGEMENT IN PADDY

Every rice crop grown is subject to at least mild disease(s) or infection(s). This is caused by fungi, bacteria, viruses, etc. In some instances, the infection becomes severe, leading to heavy crop loss(es).

Methods of disease management

Cultural methods

These methods of disease management prevent and control a disease by reducing initial disease incidence, its pace of spread, etc. Practices that reduce the initial levels of disease inoculums include the following.

Crop rotation

It is the growing of two different or more variety of crop on the same piece of land in successive seasons

or years. Rotation with non-host crops helps reduce the occurrence of some disease pathogens. Inclusion of rice and groundnut in crop rotation can control wilt disease caused by *Fusarium oxysporum f.udum.*

Summer ploughing

This operation is carried out during summer months. It results in exposing soil pathogens to heat and sunlight, which helps reduce their population, and hence, diseases caused by them.

Sanitation

Keeping the fields clean, and collection and destruction of infected plant parts after harvest reduce the occurrence of plant diseases.

Time of sowing

Sowing the crop at appropriate time reduces the occurrence of soil-borne pathogens.

Depth of sowing

Seeds sown deep in the soil catch infection(s) early, resulting in pre-emergence damping off.

High seed rate

It creates congenial environment for the occurrence of post-emergence damping off due to overcrowding.

Use of fertilisers

Diseases can be managed by using the recommended dose of fertilisers. For example, high nitrogen dose may suppress brown spots but promote the occurrence of rice blast disease and vice versa.

Green manuring

It helps in improving soil organic matter content and reducing nematode problem.

Physical method

Adoption of physical measures kills all microorganisms living in the soil, irrespective of the fact that they are harmful or useful to the plants. Some of the physical

measures commonly followed in a paddy field include dry heat treatment, hot water treatment and burning.

Biological method

In this method, beneficial and less harmful microorganisms are released to control or suppress pathogenic organisms. For example, *trichoderma* and *gliocladium* are released to control soil-borne pathogens like *rhizoctonia*, *sclerotium*, *sclerotinia* and *fusarium*.

Chemical method

This method of disease management is popular by virtue of the speed with which it brings about the desired results.

Table 2.2: Common diseases in paddy

S. No.	Name of the disease	Damaging symptoms	Control measures
1.	**Blast** (*Pyricularia grisea, pv.oryzae*)	The disease infects all aerial parts of a plant, including leaf, neck and node (Fig. 2.14 and 2.15). The name 'blast' is derived from the fact that the entire crop gives a blast or burnt appearance. There are three types of blast. They are as follows. • Leaf blast: The symptoms include brown to dark brown boat or eye-shaped lesions on the leaf surface. • Neck blast: The neck region of panicle becomes black and shrivels, leading to severe crop loss (Fig. 2.15) • Nodal blast: In this case, the nodes of the leaves turn black and break.	• Blast can be effectively controlled by seed treatment and applying *Carbendazim* 50 WP @ 2 g per litre of water for 1 kg of seeds or *Isoprothiolane* 1 ml/ha • Fungicides like *Carbendazim* 50WP @ 500g/ha or *Tricyclazole* (0.06%) 75 WP @ 500g/ha can be sprayed on the plant to control the spread of the disease at the initial stage itself.  *Fig. 2.14: Leaves infected by blast*  *Fig. 2.15: Neck blast*

2.	**Bacterial leaf blight** (*Xanthomonas oryzae pv. oryzae*)	• This disease is known as 'seedling wilt' or 'kresek'. Water-soaked to yellowish stripes with wavy margin appear on leaf blades and bacterial liquid comes out of young lesions during morning. • The cut ends of the leaf when soaked in water become turbid due to the secretion of bacterial liquid [Fig. 2.16 (a) and (b)].	• Grow tolerant variety like improved *Samba Masuri.* • Apply potassium @ 25 kg/ha after draining out water from the field. • Irrigate the field after three to four days of potassium application.
3.	**Rice tungro disease** *Rice tungro virus* (*RTSV, RTBV)*	Plants show stunted growth and reduced tillering. Their leaves become yellow or orangish yellow in colour. Delayed flowering and incomplete exertion of small panicles with sterile or partially filled grains is observed (Fig. 2.17).	• As a prophylactic measure, spray *Thiamethoxam* 25 WDG 100g/ha or *Imidacloprid* 17.8 SL 100ml/ha at 15 and 30 days after transplanting. • To avoid the survival of insect vector, vegetation on the bunds can also be sprayed with insecticides.

(a) *(b)*

Fig. 2.16 (a) and (b): Bacterial leaf blight

Fig. 2.17: Rice tungro disease

4.	**Sheath blight** (*Rhizoctonia. solani*)	The disease infests the crop in areas with high relative humidity (above 95 per cent) and moderate temperature (28–32° C). Severe infestation is found in fields with high nitrogen application. Round to irregular shaped necrotic spots are observed on the stem and leaves [Fig. 2.18 (a to d)].	• Two sprays of systemic fungicide like *Carbendazim* 50 WP @ 500g/ ha or *Hexaconazole* 75 per cent WG @ 100mg/ litre is recommended or *Thifluzamide* @ 1.5g/litre/ha. • The first spray is done at the time of disease appearance and the second after 15 days.

(a) (b) (c) (d)

Fig. 2.18 (a) to (d): Different symptoms of rice sheath blight

5.	**Sheath rot** (*Sarocladium oryzae*)	The symptoms appear at the panicle initiation stage. The stem and leaf exhibit irregular spots with dark reddish brown margins and gray centre. Discoloration of the flag leaf sheath occurs and emergence of panicles is inhibited in severe conditions. Infected panicles remain sterile, shrivelled or have partially filled grains (Fig. 2.19 a, b, c and d).	• Seed-borne inoculum can be effectively managed by seed treatment with fungicides like *Carbendazim* 50 WP @ 3g/kg seed. • Foliar spray with *Hexaconazole* 75 per cent WG @ 100mg/l is done at an interval of 15 days.

Fig. 2.19 (a): Irregular spots on leaf sheath

Fig. 2.19 (b): Discoloration of leaf sheath

Fig. 2.19 (c): Panicles remain within the sheath

Fig. 2.19 (d): Rottening of flag leaf sheath

6.	**Brown spot** (*Helminthos porium oryzae*)	This disease is the main reason behind the Bengal famine of 1943, in which millions of people lost their lives due to starvation. The disease affects rice crop in the nursery, as well as, the main field, causing seedling blight. The symptoms include round or oval brown spots of 0.5 to 2.0 mm size, which in severe conditions, merge to form large patches. The seeds are also infected, causing up to 50 per cent reduction in the yield (Fig. 2.20 a, b and c).  *Fig. 2.20 (b): Advanced stage of infection*	• Treat the seed with *Carboxin* 10 per cent and *Thiram* 10 per cent @ 2g/kg seed before sowing. • Apply systemic fungicide, such as *Carbendazim* 25 per cent @ 1g/litre+ *Mancozeb* 50 per cent WS @3g/litre or *Hexaconazole* 75 per cent WG @ 100mg/l. ha • Avoid excess use of nitrogen as it aggravates the disease incidence.  *Fig. 2.20 (a): Infected leaf*  *Fig. 2.20 (c): Circular or oval spots on leaves*
7.	**False smut** (*Ustila ginoidea virens*)	The fungal disease appears in grains and the infected grains are transformed into a yellow powdery mass, containing fruiting bodies and spores of the fungus. Mature spores look yellowish green or greenish black [Fig. 2.21 (a) and (b)].	• Two spray of *Propiconazole* 25 EC @ 500ml/ha or *Copper hydroxide* 77 WP @ 1.25 kg/ha at the stage of panicle initiation and 50 per cent at the flowering stage is needed to control the spread of the disease.  *(a) (b)* *Fig. 2.21 (a) and (b): Infested panicle*

Practical Exercise

Activity

Identify various diseases that infect paddy crop.

Material required: herbarium file, writing material, personal protective equipment like gloves, gumboots, mask, etc., and samples of plants with infestation

Procedure

- Visit a nearby paddy field and observe symptoms of some diseases appearing on paddy plants.
- Collect the disease samples.
- Put the samples in transparent envelopes and seal the envelopes.
- Make a herbarium file and paste the envelopes, containing the samples.
- Identify the diseases and label them.
- Also, write measures to control the spread of the diseases in paddy plants.
- Make a presentation before the class based on your observations.

Check Your Progress

A. Fill in the Blanks

1. The most common disease in paddy plants caused by bacteria is _____.
2. Round to irregular shaped necrotic spots appear on the stem and leaves of paddy plants in _____ disease.
3. Improved *Samba Masuri* variety of rice is tolerant to _____ disease.
4. Symptoms of false smut can be observed after the emergence of _____.

B. Multiple Choice Questions

1. _____ or kresek symptoms occur in the early stage of growth in rice plant.
   (a) Bacterial leaf blight
   (b) Bacterial leaf streak
   (c) Rice blast
   (d) False smut
2. Tungro of rice is a _____.
   (a) fungal disease
   (b) bacterial disease
   (c) viral disease
   (d) None of the above

3. The main reason of the Bengal famine was _____ in paddy.
   (a) blast disease
   (b) grassy stunt disease
   (c) brown spot disease
   (d) false smut disease
4. High dose of nitrogen application in paddy may suppress _____.
   (a) brown spot disease
   (b) blast disease
   (c) bacterial leaf blight
   (d) false smut

C. Subjective Questions

1. Describe in brief the major diseases that commonly infest paddy plants.
2. Explain the different methods of disease management in paddy plants.

D. Match the Columns

A	B
1. False smut	(a) Yellowish wavy margin on leaf blades
2. Blast disease	(b) Seed treatment
3. *Carbendazim*	(c) Affects grains
4. Bacterial leaf blight	(d) Symptoms appear on the leaves, neck and nodes of the leaves

Unit 3

Straw Management in Paddy

Introduction

Paddy straw is a by-product of paddy crop obtained after the separation of grains from the plant by threshing manually or mechanically with the help of threshers or combine harvesters. The yield of paddy straw depends on varieties, cutting height, and so on. Collection and utilisation of paddy straw is still a major challenge in the paddy straw supply chain. This straw is largely burnt *in situ*, piled or spread in the field, incorporated in the soil or used as mulch or simply carried away from the field for use in livestock paddock. The straw is also utilised as feed stock for different industries.

Characteristics of Paddy Straw

Uncompressed paddy straw has specific weight of 70–80 kg/m^3 at a moisture content of 15–18 per cent. Rice husk contains high amount of silica, which creates hindrance in processing machines (conveyers or grinders). For the same reason, it does not qualify as a quality feed as its digestibility in livestock is hampered without pre-conditioning.

C:N Ratio of Paddy Straw

C:N ratio is defined as the ratio of percentage of Carbon to that of Nitrogen in an organic material. The C:N

ratio of dry paddy straw is 60:1 to 80:1 as against the required or recommended range from 10:1 to 25:1. Decomposed paddy straw may not be conducive to crop growth. Therefore, farmers often burn it in the field.

Methods of Paddy Straw Management

Paddy straw is commonly used for bedding purpose in paddocks. It is not considered fit for animal feed. It is either dumped into rivers or burnt in the field. This causes contamination of water and air with greenhouse gas emissions. Therefore, paddy straw burning is banned in some countries. However, several technologies have been developed to utilise paddy straw, which are described as follows.

Burning

Burning of paddy straw in field dispenses the effort or labour required to remove large quantity of straw piled in from the field. It is assumed that burning paddy straw in the field helps to control weed, insects–pests and diseases. But burning of paddy causes an adverse impact on soil health like depletion of organic matter and environment. Besides, it poses a threat to beneficial soil microorganisms. Burning of paddy straw is also known to emit harmful greenhouse gases like Carbon dioxide (CO_2) and pollutants like Sulfur dioxide (SO_2), Nitric oxide (NO), etc.

Use as manure

Incorporation of paddy straw is not practised by farmers because it may not get decomposed completely within three to four weeks. Microorganisms like *Tricoderma* have been identified to speed up paddy straw decomposition rate. Cutting up of paddy straw by dry chopper is said to achieve faster decomposition with the help of inoculums. Paddy straw, however, is now finding wide application as a growing medium for mushroom cultivation. The waste paddy straw from animal bedding further finds use as raw material for making compost or manure for crop production.

Compost making

Compost brings organic matter to such a form, which provides required nutrients to the crop, and simultaneously, maintains soil health. For the preparation of compost, paddy straw is chopped and soaked in 0.1 per cent urea solution. The moisture level is maintained at 60 per cent. To this, slurry straw is added from a biogas plant and an equal amount of chopped green matter of some leguminous plant is laid, which covers a layer of 15 cm. The already prepared pit, is, finally, covered with a plastic sheet. Turning the compost material during the period of decomposition is necessary to maintain the temperature and oxygen level. This exercise must be done at an interval of every two weeks. After 90 days of composting, the compost is ready for use. In case, turning is not done, the temperature of the pit will rise, which is not favourable for microorganisms.

Paddy straw bailing

Transferring paddy straw from the field to the location of its use is a major challenge because of its voluminous nature. Paddy straw can be compressed and made compact as rolled up bales. A machine called 'baler' is used to make straw bales (Fig. 3.1). Once baled, the straw is amenable to be easily transferred, leading to reduction in the transportation cost. However, in the present scenario, combine harvesting is more prevalent. The straw remaining after combine harvesting is not easy to bale.

Fig. 3.1: Rice straw bales

Industrial Uses of Paddy Straw

Paper making

Any lingo-cellulosic material can be used as feed stock for paper and pulp industry. Paddy straw is also a lingo-cellulosic material. Therefore, it can be used for paper making. Paddy straw can be easily pulped and is less harsh for cooking as it contains less lignin as compared to wood pulp.

Biomass to produce energy

Paddy straw can also be used to prepare a briquette and as fuel in a brick kiln. It can be used to generate energy either alone or after being mixed with some other biomass, having high methane producing capacity, thereby, enhancing its energy producing efficiency.

Packing material

High silicon content and resistance to crushing makes paddy straw a desirable material for packaging. Paddy straw provides an environment friendly option for packing. It can also be used as filling material and serve as an alternate to thermocol, plastic, etc. Straw mat and envelopes for wine bottles can also be made out of paddy straw. It can be used for making disposable food packages as well.

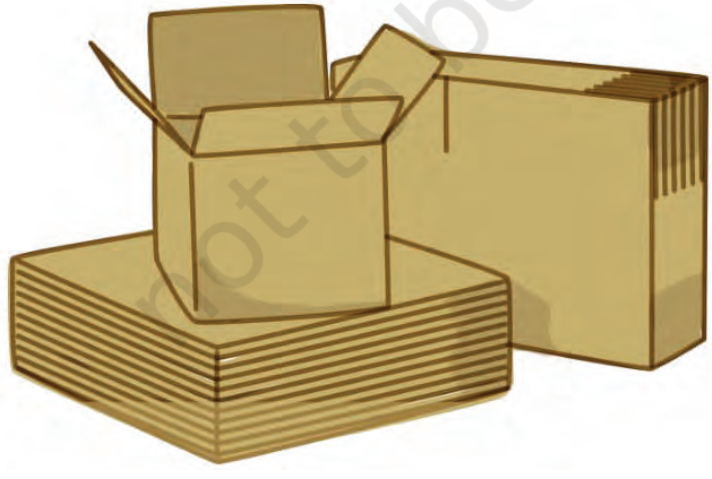


Fig. 3.2: Paddy straw as a packing material

Mushroom cultivation

Paddy straw has high utility as a medium for growing mushrooms in winters or under controlled temperature control conditions. Paddy straw mushroom (*Volvariella volvacea*) and Oyster mushroom (*Pleurotus spp.*) are delicious, as well as, nutritive.

Ropes

The presence of high fibre and mineral content gives tensile strength to paddy straw, making it suitable for making ropes. Ropes made of paddy straw are commonly used in thatch work, packaging industry and iron foundries.

Fig. 3.3: Paddy straw rope

Practical Exercise

Activity

Enlist the various uses of paddy straw.

Material required: writing material and chart paper

Procedure

- Collect information about varrious uses of paddy straw from the Internet.
- Write about various products that can be made with paddy straw.
- Now, give a presentation before the class.
- Allow feedback and discussion on the topic.

Check Your Progress

A. Fill in the Blanks

1. A by-product of paddy obtained after the separation of grains from plants by threshing is called the _____.
2. Rice husk contains a high amount of _____, which creates hindrance in processing machines.
3. Fungal inoculums called _____ are used to speed up the decomposition of paddy straw.
4. The process of collecting and bundling of paddy straw is known as _____.
5. The machine used for making straw bales is called a _____.

B. Multiple Choice Questions

1. Burning of paddy straw emits _____ greenhouse gas(es).
   (a) CO_2
   (b) SO_2
   (c) NO_2
   (d) All of the above
2. Paddy straw compost becomes ready for use after _____ days.
   (a) 120
   (b) 90
   (c) 60
   (d) 30
3. What is the C:N ratio of dry paddy straw?
   (a) 20:1 to 30:1
   (b) 40:1 to 50:1
   (c) 60:1 to 80:1
   (d) 90:1 to 100:1

C. Subjective Questions

1. Describe the methods of paddy straw management.
2. Write the process of paddy straw compost preparation.
3. Explain the uses of paddy straw.

D. Match the Columns

A	B
1. Paddy straw rope	(a) *Volvariella volvacea*
2. Paddy straw mushroom	(b) Paper and pulp industry
3. Lingo-cellulosic material	(c) *Pleurotus spp.*
4. Oyster mushroom	(d) Thatch work

NOTES

Unit 4

Harvesting and Storage

Introduction

Harvesting is an important operation in crop production. But the yield is often lost due to inappropriate harvesting and threshing practices. Some varieties of rice tend to ripen non-uniformly, especially, under irrigated conditions. Also, frequent rains and lack of continuous sunlight during the harvesting period make harvesting of the crop difficult. Grains, even on the same panicle, ripen at varying rates. Early harvesting may carry green grains and cause rotting. On the other hand, late harvesting of the crop leads to over ripening of the grains and shattering losses. Furthermore, unnecessary delay exposes the grains to increased bird attack, which may also adversely affect the yield and total produce.

Harvesting the crop at appropriate time is important to check crop loss and maintain quality grains, which implies high market value for the produce. The crop must always be harvested at physiological maturity or harvest maturity. The harvest time also affects the germination potential of paddy seeds. After the harvesting of paddy crop, it must be threshed immediately to maintain the quality of the grains. Over drying of harvested paddy for several days must be avoided as it affects the grain quality. It is advisable to clean the grains for packaging and storage purposes.

Harvesting, Threshing and Winnowing

Harvesting

It is one of the most important phase of crop production, wherein, ripened crop is collected from a field. Harvesting, therefore, implies cutting and collecting mature crop from the field. The processes sequentially involved in harvesting are reaping, stacking, threshing, cleaning, packing and hauling. These processes can be done either manually or mechanically. Application of recommended harvesting methods can help maximise the yield and improve the quality of grains, thereby, minimising grain damage, loses or deterioration.

Before a farmer plants the crop, one must decide how and when to till the field. Tilling prepares the soil so that the seedlings can be planted. Tillage begins after the last crop is harvested.

Points to note

- At about 35 days after flowering, it is time to start thinking of harvesting the paddy crop.
- Green grains should not be more than four to nine per cent at harvest time.
- Grains at the milky stage should normally be less than one per cent.

Time and stage for harvesting

Timing in harvesting operation is important to achieve high market value of the produce with a high consumer acceptance. When approximately 80 per cent of the panicles turn golden yellow and the grains contain about 20 per cent moisture, it is the right time and stage for harvesting [Fig. 4.1(a) and (b)].

(a) (b)

Fig. 4.1 (a) and (b) : Stage of harvesting

Methods of harvesting

Harvesting can be carried out manually, as well as, mechanically. Combine harvesters are now widely being used for harvesting of paddy crop. Using combine

harvesters is efficient than manual methods of harvesting. The time required for carrying out the entire operation with the help of combine harvesters reduces by 70–75 per cent compared to manual methods.

Manual harvesting

Manual harvesting is the most popular method of harvesting paddy crop in India. This method is in practice for centuries. Paddy crop is cut with the help of sickles at a point, leaving about 15–20 cm culm into the ground. The sickle to be used must be sharp and serrated. Using sickle for cutting paddy crop needs

(a)

(b)

(c)

(d)

(e)

Fig. 4.2 (a to e) : Stages of manual harvesting

expertise so that fingers, thumb and skin do not get injured in the process [Fig. 4.2(a to e)]. While cutting the crop with a sickle, one must always hold the stems with the thumb, pointing upwards (away from the blade).

Advantages

Hand or manual method of harvesting has the advantage of ease of operation. There is no other alternative for harvesting paddy under lodged crop conditions. When other means are not affordable or weather conditions do not permit the use of mechanical methods, then manual methods are suitable.

Disadvantages

It is a labour intensive and time-consuming process, subject to weather conditions. It requires five to ten people to carry out the work manually.

Mechanical harvesting

Harvesting by reaper

Crop cutting machines used for reaping (machines that cut and gather) are called 'reapers'. These machines are useful in carrying out harvesting on small land holdings and may be hand-driven, mechanised or tractor-mounted. Most reapers lay the crop row-wise aside the re aper line (to be picked up later). The cutting width of reapers is, generally, 1.5 metre and they can deliver harvest to the extent of 2–4 ha/day. Their efficiency goes up if the fields are leveled and dry. Water must be drained out 10–15 days before starting the harvesting operation.

Combine harvesting

Combine harvester is a machine, which is more efficient than any other method of harvesting and combines all operations, such as cutting the crop and feeding it into a compact sequential process (reaping, threshing, cleaning, packing and transferring it to packing or storage bags or bulk wagon). The cut up straw is, usually, discharged behind the combine in a windrow and can be piled up safely for various uses later.

Threshing

It is the process of separating grains from a straw. It is done by stacking small bundles on a platform or using mechanised equipment. Pedal threshers are also being used these days. Heavy duty power-driven stationary threshers are used for quick large-scale threshing. Threshing can be done both manually and mechanically.

Manual threshing

Trampling

It is an ancient and traditional method of threshing, wherein, farm animals like bullocks are made to walk in the field and trample the crop bundles spread loosely over a mat, tarpaulin or canvas with their hoofs. It is carried out either in the field itself or in the village compound, which, generally, has a threshing floor. After the grains are separated from the straw, they are cleaned by winnowing with or without the help of a winnower (man-operated fan, mechanically or electrically operated fan; see [Fig. 4.3 (a) and (b)].

(a) (b)

Fig. 4.3 (a and b): Manual threshing

Threshing table or rack

The harvested sheaves (stalks with panicles on top) are held by hand and beaten against a slatted bamboo, wooden or any hard stationary object *viz.*, steel or empty oil drum. As a result, the grains come out of the panicles and get collected on the ground. This is a labour-intensive process. However, varieties with easy thresh ability make the process easier.

Pedal thresher

The constituents of a pedal or treadle thresher include a threshing drum, transmission unit, foot crank and base (strong and stable). When pedaled, the drum rotates and functions as a threshing drum. Holding the crop against the rotating drum with spikes or rasp bars of the thresher operated manually or electrically is better than a human powered one. The threshed material contains small straws, chaff and foreign matter. These must be further separated by winnowing and sieving.

Fig. 4.4: Manual paddy thresher

Mechanical threshing

Use of portable threshers is perhaps the first step in the introduction of mechanical threshing for paddy crop. Its major advantage is ease of operation and reduction in the labour required. Stationary or immovable threshing is, generally, done in the field or near the field. Also, there is an option of using a pedal thresher, a tool used to improve manual threshing.

Small stationary machine thresher

This machine has mostly replaced manual threshing. Mechanical threshers are kept in the field or close to it. The rotating drums constitute the threshing component in the threshers. These may be peg toothed or blade toothed (wire loop or rasp bar type; see Fig. 4.5).

Fig. 4.5: Power-operated paddy thresher

Large machine thresher

It has the added advantage of cleaning devices like an oscillating screen, centrifugal blower and wind board. Threshed grains, in this case, do not demand further cleaning. In many locations, machine threshers are available on custom hiring basis. Many of these custom hired machines are tractor driven, which enable the operator to cover field-after-field as per the schedule.

Guidelines for threshing

- Put the harvested crop for drying on a safe surface. The dried crop material must not be re-wet as it is harmful.

- Less the moisture content in grains, less is the grain loss in threshing. Best results are obtained at 18–20 per cent grain moisture content.

Combine threshing

It is a machine that combines a series of operations, starting from reaping up to packing in bags, and removing stalks and unwanted material from harvested grains (Fig. 4.6). In India, the use of combine harvesters (or simply, 'combines') has increased rapidly over vast areas. A shift from manual or other mechanical means has been triggered by labour shortage and consequent increase in harvesting cost, which makes the use of combines economically attractive.

Fig. 4.6: Combine harvester used for threshing

The functions a combine harvester performs are as follows.

- Reaping: Cutting the crop above the ground surface after leaving about 15–20 cm clumps into the soil.
- Threshing: Separating grains from rest of the cut crop.
- Cleaning: It involves removal of immature, unfilled and non-grain material.
- Bagging: It involves packing threshed grains into bags for storage or transportation. Sometimes, the threshed grains are simply poured into an open

trolley for direct transportation, if bagging is to be avoided, or in case, not considered necessary.

- Hauling: It entails moving the cut crop material to a desired location for threshing.

Cleaning or winnowing

It refers to the removal of lighter material, such as unfilled grains, chaff, weed seeds and straw from grains with the help of blower, air fan or wind. Winnowing retains only the heavier grains.

Sifting or screening

Weed seeds, undefined hard material or soil particles (1.4 mm or less), if any, are removed by sieving.

Winnowing procedure

- Place a sheet or mat on the ground.
- Put grains on a winnowing tray.
- Tilt the tray from a height of about 1.5 to 2 metre to let the grains fall against the wind, so that light grains can be separated and pushed away from heavy grains.
- Collect only the heavier grains.
- Repeat the procedure, if required.
- A fan or blower is recommended, if sufficient wind is not blowing.

Storage of paddy

A grain storage facility is required to provide congenial conditions for the safety and long life of stored material. It implies prevention of loss by adverse weather conditons, moisture, rodents, birds, insects, microorganisms or pilferage. During storage of paddy (with husk), husk provides protection against insects and also helps check deterioration of grain quality, etc. Hulled rice occupies 20 per cent less storage capacity. Under tropical humid conditions, brown unpolished rice has a short shelf life (of about two weeks).

Table 4.1: Problems associated with the storage of grains with different moisture content

Grain moisture content (%)	Safe storage	Problems
14 or less	3 weeks to six months approximately	Fungal growth, discolouration and respiration loss
13 or less	8 to 12 months	Damage by insects
12 or less	Farmer's seeds	Loss of germination
9 or less	More than 1 year	Loss of germination

Source: Rice Knowledge Bank, International Rice Research Institute (IRRI), Manila, the Philippines

What does safe storage imply?

Safe storage implies preventing or minimising the entry of moisture into the storage area and grains. Rice grains having high moisture content may get spoilt in storage. Some of the points that need to be taken care of for the safe storage of grains are as follows.

- Safety against insects–pests, rodents, birds, etc.
- Ease of loading and unloading within and outside the storage premise.
- Efficient use of storage space for placing and retrieval of stocks.
- Electricity and water supply with ease of maintenance and management.

Rice storage facilities

Storage systems can be in open, bulk, sealed (hermetic) containers or bags. Rice storage facilities may vary according to the quantity to be stored, purpose of storage, location, etc.

Bag storage

This implies storing grains in 40 or 80 kg jute or woven plastic bags. In a rural setting, any kind of large vessel becomes a storage material.

Bulk storage

A common storage material used in India is a jute bag or woven plastic bag (40 or 1000 kg capacity). Depending on the size of storage, these bags are, normally, arranged into stacks.

Hermetic storage

Grains are stored in an airtight container so that moisture content of the stored grains remains unchanged. This system helps increase the life of seeds, maintain high germination rate and control stored grain pests.

Some of the points that need to be taken care of while storing rice grains are as follows.

- The dimensions and design of the storage must be amenable to sealing and fumigation. Do not stack bags one over the other to a height exceeding 4 metre for jute bags and 3 metre for plastic bags (less stable and prone to slippage).
- Provide a year-round water-proof facility at roof and enclosure (concrete, asbestos, tarpaulins or polythene covers).
- A 15–cm clearance must be provided from the ground (with a plank device), and likewise, a 1.5–metre clearance must be maintained between the top of the stack and roof. Sufficient walking space is also needed, say a one–metre gap between and around stacks.
- Do not use an accessory or material (for example, paddy straw or old bags) that may be prone to inviting insects–pests, diseases, spores, etc.
- A hermetic liner bag may be used, especially, for storing seeds. The bag may even be used for storing commercial paddy and rice grains.
- These must be designed to cater to intermittent marketing schedules and plans.

Maintaining hygiene in storage

- Keep the storage areas clean by sweeping the floor, removing cobwebs, dusting and removing bird spills, if any.
- After emptying the storage rooms, clean the space. It is advisable to spray the walls, crevices and floor with an insecticide. Also, fumigate these areas before using them for storage again.
- The storage rooms must be kept free of vermin.

- Periodic inspection of stored seeds is recommended for signs of infestation. If necessary, corrective measures must be taken immediately.

Practical Exercise

Activity 1

Visit a nearby paddy field and observe harvesting and threshing process being carried out there.

Material required: notebook and writing material

Procedure

- Visit a nearby paddy field, where crop has reached the maturity stage.
- Observe and note down the colour of the panicles and plant, hardness of grains, etc.
- Observe the harvesting process.
- Observe if the harvesting process is being carried out manually or a harvester is being used.
- Note down the functions of the harvester.
- Also, note down the steps being followed in case manual harvesting is being carried out there.
- Present your findings before the class.

Activity 2

Visit a nearby warehouse and observe the storage of rice grains.

Material required: notebook and writing material

Procedure

- Visit a warehouse in your area.
- Observe and note down the method being followed there to store rice grains.
- Discuss with the store manager the measures being followed there to store the grains safely.
- Present your findings before the class.

Check Your Progress

A. Fill in the Blanks

1. The process of cutting and collecting mature crop from the field is known as _____.
2. The right stage of harvesting paddy crop is when most of the panicles turn _____ in colour.
3. The process of separating grains from straws is called _____.
4. Generally, paddy crop is ready for harvesting after _____ days of flowering.

5. Rice grain with its hulls removed but not polished is called _____.
6. When grains are too moist, it may result in _____ during storage.
7. Rice grains may be stored for more than one year with the moisture content of _____ per cent or less.

B. Multiple Choice Questions

1. Drain the rice field _____ day(s) before harvesting.
   (a) one
   (b) five
   (c) seven–nine
   (d) 10–15
2. Which of these combinations identify the first and last activity in the process of harvesting?
   (a) Reaping and cleaning
   (b) Reaping and handling
   (c) Reaping and stacking
   (d) Reaping and hauling
3. The appropriate time for harvesting of paddy crop is when the grain moisture content reaches below _____ per cent.
   (a) 10
   (b) 20
   (c) 30
   (d) 40
4. The process of separating unfilled grains, chaff and straws from the grains is known as _____.
   (a) reaping
   (b) winnowing
   (c) threshing
   (d) hauling
5. What is the shelf life of unpolished brown rice under tropical conditions?
   (a) One week
   (b) Two weeks
   (c) Three weeks
   (d) Four weeks
6. What is the optimum capacity for bag storage?
   (a) 20 or 40 kg
   (b) 30 or 90 kg
   (c) 50 or 100 kg
   (d) 40 or 80 kg

C. Subjective Questions

1. Write the different stages of paddy crop harvesting.
2. Discuss the methods of paddy crop harvesting.
3. Describe threshing and its methods.
4. Define storage and explain various rice storage facilities.
5. Write in brief how you will maintain hygiene in the storage of rice grains.

D. Match the Columns

A	B
1. Machine threshing	(a) Shatter loss
2. Pedal thresher	(b) Winnowing
3. Cleaning	(c) Mechanical threshing
4. Late harvesting	(d) Better than manual threshing
5. Hermetic storage	(e) 20 per cent less storage capacity
6. Hulled rice	(f) Made of jute
7. Storage bag	(g) Airtight containers

Unit 5

Paddy Marketing

Introduction

With emphasis on commercialisation of agricultural production, attention to agricultural marketing becomes a priority. Marketing encompasses transaction of goods and services, starting from the producer(s) to consumers. It also denotes a place or region, where buyers and sellers interact freely, and exchange of goods and commodities takes place between them. The value, cost and price of the items traded are as per the forces of demand and supply.

Market

The word 'market' is derived from the Latin word 'marcatus' *viz.*, merchandise or trade or a place meant for buying and selling of goods. Market is also used to denote a premise, where one or more commodities are bought and sold. It, therefore, refers to a meeting place for potential buyers and sellers of a particular product or service.

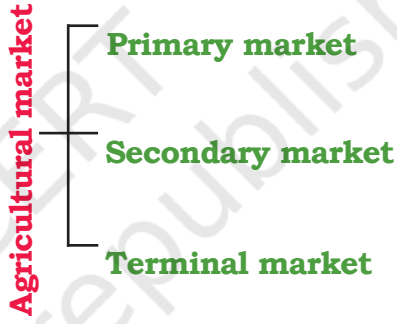
The constituents necessary to satisfy the presence and purpose of a market are as follows.

- Availability of goods or commodities for transaction (physical presence not mandatory)
- Availability of active buyers and sellers
- Operation of business transaction between buyers and sellers

Classification of market

A market is a place, where the transaction of goods, commodities and produce between buyers and sellers takes place. Agricultural produce passes through several exchanges from one entity to another, before finally reaching the consumers. These exchanges include assembling, preparation for consumption and dispersion of goods, commodities and services.

Marketing of a good or service depends on its demand at a given time. The sphere of a market may extend to a locality, village, town, region or country, according to the demand of the commodity or service. A market may be a physical or virtual entity. It may be local or global, perfect or imperfect, daily, weekly, monthly or seasonal, depending on its existence and occurrence.



Agricultural market

Primary market

It is also known as 'fresh produce market'. Here, the transaction is conducted between producers and buyers once or twice a week. The business involves primary goods or commodities, such as food grains, livestock, raw material, etc. Wholesalers or commission agents abound in these markets, where agricultural produce comes from nearby villages. As per their location, these are also often referred to as 'village markets'.

Secondary market

Produce and commodities procured from the primary market are bought and sold here. The transactions are

done directly from a seller and by the commission agent or broker (as an intermediary). These are also known as *mandi*s and are situated, generally, in a district or *taluka* or important trade centres near railway stations. The produce is handled in large quantities. Merchants procure products from the primary and wholesale markets and bring them to this market for sale.

Terminal market

This is the one that delivers products to the actual consumers or exporters. These are, generally, high value or high volume markets, operating on electronic devices or 'over the counter'. These markets are endowed with large warehouses and storage facilities. There is abundant space for logistics and packaging to provide the material in finished form. These markets are located in metropolitan cities, such as Chennai, Mumbai, Kolkata, etc., being close to the port of assembly, loading and shipment. Directly or indirectly, the activities of terminal markets influence the activities and operations in the primary and secondary markets.

Based on time span

Daily market

These markets are organised only for few hours in a day. They mostly deal in items of fast turnover or those that are perishable in nature (for example, fish and meat, vegetables and fruits, eggs, etc.).

Weekly market

Held once a week, these markets are also referred to as *haats*. The products and commodities can be stored for some time (food grains, oilseeds, etc.). The prices of the commodities are largely governed by local supply and demand.

Seasonal market

These markets deal in commodities that are seasonal in nature. But since different commodities are available in different seasons throughtout the year, these markets

operate almost permanently. The items may or may not be perishable with facilities for short to medium term storage.

Market channel

The pathway, covering the transfer of the title of a commodity, is called its marketing channel. It is the route taken by a product in moving from its original owner to the processor, and then, to the ultimate consumers.

- The participants in the channel vary according to the commodity and quantities handled.
- The task of distribution or market channel system is to match the demand with appropriate supply.
- All goods go through a series of channels of distribution before, finally, being delivered to the consumers.

There are two main types of channel for the distribution of a commodity — direct and indirect.

Direct distribution

In this channel, products or services reach directly to the consumers from the producer or manufacturer. The service sector is the best example for this kind of distribution. In agriculture, such transaction takes place in products, which need little or no processing before marketing or in case of perishable produce like milk and milk products, mushroom, etc., which need to be sold within a specific timeframe.

Indirect distribution

This occurs when intermediaries are involved in the distribution channel. In the marketing and distribution of agricultural produce, the intermediaries would be farmers or local dealers, who collect the produce from the farmers, wholesalers (who buy the produce from local dealers) and retailers, who sell the produce to the consumers. As the number of intermediaries increases in a channel, the price of the products also goes up, especially, for the consumers.

Factors governing a product's channel

- Nature of the product
- Price of the product
- Volume or number of units for sale
- Characteristics of buyers and their buying units or users
- Retailers dominating the distribution and sale of low priced articles with small packaged units
- Costly items like rotavators, sowing machines, etc., being sold directly by manufactures or their agents
- Public services like gas, electricity and transport, usually, being sold directly to the consumers

Channels of distribution

- Producer → Consumers
- Producer → Retailers → Consumers
- Producer → Wholesalers → Retailers → Consumers
- Producer → Commission agents → Rice mill owners → Retailers → Consumers

Producer → Consumers

A manufacturer or producer directly sells a product or produce to the consumers. Intermediaries or agents are not at all involved in this kind of sale. This would often include custom-made products like a specially designed seed-cum-fertiliser drill or no-tillage planter, etc.

Producer → Retailers → Consumers

In this channel, a producer sells one's products to retailers and the retailers, then, sell them directly to the consumers. This channel works best for farmers to sell their produce and meet their immediate needs as consumers need more time to decide to purchase a commodity. If storage facilities are not available with a farmer or seller, it is in the person's interest to sell the commodity to a trader before it, finally, reaches the consumers. This kind of channel is beneficial for low

volume transactions, where the assortment of goods and products is broad. The role of intermediaries is vital in establishing correspondence between demand and supply in the distribution business.

Producer → Wholesalers → Retailers → Consumers

Such a large channel is used by manufacturers, whose products have an extended or delayed market, for example, clothes, furniture, cutlery, etc. Consumers may take time to decide the item they want to buy. They may try out many items and collect information about them before, finally, making a purchase. This channel is a favourite among manufacturers for non-food shopping goods.

Producer → Commission agents → Rice mill owners → Retailers → Consumers

Such a distribution involves more than one intermediary and a commission agent, who assists with the sale of a product. Agents, usually, receive commission from both the parties. For small farmers with small land holding, sale of paddy in *mandis* is a profiatable option. Considerations of the cost for logistics prevent rice processing companies from making direct purchase from the farmers. The mill, thus, purchases the produce from the intermediaries and processes the grains. This, in turn, is marketed across States through a network of commission agents and retailers.

Krishi Upaj Mandi

A large number of small and marginal farmers sell their produce to traditional moneylenders (traders), to whom they may be indebted for years. Products are also sold in various other ways, *viz.*, weekly village market in the farmer's or neighbouring village. In the absence of these outlets, the produce might be sold unconventionally at sporadic, irregularly held markets close to their place of work.

Under the Agricultural Produce Market Committee (APMC) Act, 1937, as many as 40 commodities are compulsorily upgraded or value added for export and voluntarily graded for home consumption. Commodity markets are regulated by States. To help set up commodity upgrading centres in identified markets, the Directorate of Marketing and Inspection, Government of India, provides services for requisite financial aid at the village level.

Role of APMC or Krishi Upaj Mandi

Krishi Upaj Mandi (KUM) plays a latent role in price fixation of agricultural produce between the buyers and sellers. The government fixes the Minimum Support Price (MSP) for notified agricultural produce. Such produce cannot be sold at a price below the declared MSP. No bid is permitted to start in the market yard below the rate as fixed.

The farmers are obliged to take the produce of 40 identified commodities to the Agriculture Produce and Livestock Market Committee (APMC) or *Krishi Upaj Mandi* for sale, except when they engage in small-scale sale at local *haats*. The *mandi* board (APMC or KUM) follows the prices fixed by the Government of India as the MSP. These prices are displayed in the market yards for the benefit of the farmers. This information is useful to the farmers for better decision making as regards to the sale of their produce. But not all commodities are covered by the Central Consumer Protection Council (CCPC).

The details on arrivals and prices of different agricultural commodities are uploaded at the AGMARK NET portal for information and guidance. This can also be viewed on the APMC portal of different States. The farmers can visit this site and make their decisions as regards to the sale of their produce.

There is a regulation, which demands that the price of a notified agricultural commodity coming to the market yard for sale is decided by a tender bid or open auction. No deduction is permitted to be made from the agreed price for any reason whatsoever.

Practical Exercise

Activity 1

Visit a nearby grain market and note down the following observations.

Material required: notepad and writing material

Procedure

- Visit a nearby grain market.
- Enlist the different channels of marketing that you find there.
- Observe the different types of transaction taking place in the market.
- Note down all the information that you have collected in a notebook.
- Present your observations before the class.

Activity 2

Visit a nearby *Krishi Upaj Mandi* and enlist the details of various commodities and market activities that you observe there.

Material required: notepad and writing material

Procedure

- Visit a nearby *Krishi Upaj Mandi.*
- Enlist the details of various commodities and other market activities that you observe there.
- Talk to the authority concerned to find out how the Minimum Support Price is determined and how the price for a particular commodity fixed.
- Record your observations in a notebook.
- Present your findings before the class.

Check Your Progress

A. Fill in the Blanks

1. A market, where commodities are received directly from farmers, is known as _____ market.
2. The prices in a primary market are _____.
3. The prices _____ in a secondary market, depending on the demand and supply of the commodities traded.
4. The intermediaries through which farmers' produce reach consumers are called _____.
5. The Minimum Support Price of agricultural commodities is fixed by the _____.

B. Multiple Choice Questions

1. The marketing channel more suitable for custom-made products is _____.
   (a) Producer ⟶ Consumers
   (b) Producer ⟶ Retailers ⟶ Consumers
   (c) Producer ⟶ Wholesalers ⟶ Retailers ⟶ Consumers
   (d) Producer ⟶ Commission agents ⟶ Wholesalers ⟶ Retailers ⟶ Rice mill owners ⟶ Consumers
2. Which is also known as fresh produce market?
   (a) Primary market
   (b) Secondary market
   (c) Terminal market
   (d) Seaboard market
3. When middlemen or intermediaries are involved in the distribution channel, it is known as _____.
   (a) direct distribution
   (b) indirect distribution
   (c) direct and indirect distribution
   (d) All of the above

C. Subjective Questions

1. Distinguish between the following.
   (a) Primary and secondary market
   (b) Daily and weekly market
   (c) Terminal and seasonal market
2. Differentiate between the following.
   (a) Direct and indirect marketing
   (b) Wholesaler and retailer

D. Match the Columns

A	B
1. Daily market	(a) Without intermediaries
2. Weekly market	(b) Regulated market
3. *Krishi Upaj Mandi*	(c) Perishable produce
4. Direct distribution	(d) *Haat*

NOTES

Unit 6

Handling Emergency Situations during Paddy Crop Production

Introduction

Paddy crop mostly faces aberrant weather conditions in different parts of the country. The south-west monsoon rains, which are seasonal, erratic and highly variable in nature with respect to region and time, are a major source of water for the crop. The crop yields are considerably affected due to the vagaries of monsoon rains in different parts of the country every year. Therefore, knowledge related to weather conditions is essential for rice growers. Besides, they must know the ways and means to tackle these situations.

Managing Aberrant Monsoon Conditions

Aberrant monsoon

- Delayed arrival or onset of monsoon
- Timey onset of monsoon followed by prolonged dry spell
- Early withdrawal of monsoon
- Extended monsoon

Delayed onset of monsoon

When monsoons are delayed, the variety to be grown differs from normal. A delay of up to 10 days

may not warrant a change in variety. But a delay of more than 20 days will demand that a relatively early maturing variety replaces the existing one. If it is further delayed, then an early variety will be an ideal choice for planting.

Provision for irrigation at weekly interval and other normal needs of nursery rising should be adequately managed so as to raise the nurseries successfully. Long duration variety (>140 days at three to four weeks old) seedlings stage must be transplanted by the first fortnight of July. In case monsoon is delayed for up to four weeks, the second nursery should be taken. For medium duration, cultivars (125–135 days) of three to four week–old may be used and transplanting may be done in the third or fourth week of July. If further delay is anticipated, the third nursery must be used. Short duration varieties (<110 days) are also used for transplanting. A three to four week–old seedling must be transplanted in the first fortnight of August.

Early withdrawal of monsoon

Suspension of *Rabi* crop after paddy is cultivated is one essential outcome, if monsoon is below average. However, moisture conservation is integral to effective and efficient utilisation of available resources. The following moisture conservation practices are beneficial.

- Plant density must be reduced and adjustment of plant population be done before 30–35 days after sowing.
- Surface mulches can be used to conserve moisture in the crop.
- Protective irrigation must be carried out at 55–56 days of growth.
- The frequency of interculture must be increased (prevent loss of moisture).

Extended monsoon

The timing of harvesting paddy becomes tricky under continued rainfall conditions. One must try to harvest the

crop on a dry day and the crop bundle after harvesting must be moved to a covered but open area for early threshing. Do not pile the harvested paddy bundles too high. Turn them to provide an airy environment. However, this practice is rarely experienced. Double cropping must, preferably, be adopted in medium deep soils. The choice of additional crops depends on the soil and weather conditions, as well as, the best commodity market at hand.

Aberrant monsoon conditions

Monsoon sets into effect due to seasonal reverse in the wind direction during the monsoon season. Historical analysis of rainfall distribution pattern in India depicts the following features.

- Monsoon rains over the years and rainfall pattern in different regions in India are known to be highly variable in nature and often erratic.
- There is large variation in the onset dates of south-west monsoon every year across different locations in the country.
- Being extended and prolonged in time and space, monsoon rains are beset with dry spells, ranging from few days to weeks with intermittent wet spells.
- Just like onset, a large yearly variation occurs in the dates of cessation of south-west monsoon in different parts of the country. Often, an early withdrawal of monsoon is experienced in some parts of the country.
- The quantum of individual precipitation and cumulative rainfall also varies with space and time across the country.
- Run-off and drainage problems often follow cyclones and depressions, accompanied by high intensity rainfall.

Effects of aberrant rains on crops

The unfavourable changes in rainfall pattern create different kinds of drought *viz.*, early season, mid-season, late season, chronic and apparent, which have been discussed as follows.

Early drought condition

Delayed onset of monsoon is referred to as early season drought. This is aggravated later by a prolonged dry spell soon after the onset of monsoon. This drought causes seedling mortality, poor crop stands and poor crop growth. There is reduced water availability for crop growth, which hampers vegetative growth of crop plants, as well as, reproductive performance of the crop.

Mid–season drought

This phenomenon is characterised by insufficient soil moisture between successive or sequential rainfall events during peak crop growth period. The impact of mid–season drought depends on the crop growth stage, and duration and intensity of the drought spell.

Terminal or late season drought

Cessation of monsoon much before the normal time with or without late commencement or weak monsoon activity leads to terminal or late season drought. This is critical as it adversely affects the reproductive stage of the crop, even in case of wetland rice.

Chronic drought

This type of drought is common in arid areas, where rainfall and stored soil moisture are inadequate to meet the crop's water requirement during most of the year. The crop growing period in these areas is hardly six to seven weeks.

Apparent drought

Mismatching moisture needs of the crop in time, relative to rainfall pattern, is responsible for the incidence of apparent drought. Such drought conditions occur in medium to low rainfall regions.

Tackling aberrant weather conditions

Crop management practices

The following measures must be followed to tackle aberrant weather conditions.

- Conservation of water and its efficient utilisation towards crop management

- Effective weed management during critical phase
- Mulching and increased inter culture operation
- Crops like millets, red gram and castor are drought resistant in nature. Such crops must be selected, so that they are able to sustain longer dry spells.

Practical Exercise

Activity

Enumerate some measures that you would take to tackle aberrant weather conditions in case of paddy cultivation.

Material required: practical file and writing material

Procedure

- Collect information about aberrant weather conditions that hamper paddy crop cultivation.
- Write some measures that you would take to manage aberrant weather conditions in case of paddy cultivation.

Check Your Progress

A. Fill in the Blanks

1. _____ monsoon rains are a major source of water for paddy.
2. Rainfall over different regions in India is known to be highly _____ in nature.
3. Delayed onset of monsoon is referred to as _____ drought.
4. Insufficient availability of soil moisture during peak crop growth period is known as _____ drought.
5. Chronic type of drought is found in _____ areas.

B. Multiple Choice Questions

1. Early withdrawal of monsoon affects suspension of _____ crop.
   (a) *Kharif*
   (b) *Rabi*
   (c) *Zaid*
   (d) Summer
2. At which crop growth stage, protective irrigation should be carried out?
   (a) 55–60 days
   (b) 75–80 days
   (c) 25–30 days
   (d) 95–100 days

3. Under which monsoon condition, double cropping is possible in medium deep soils?
   (a) Extended
   (b) Early
   (c) El-Nino
   (d) La-Nina
4. The frequency of inter culture helps in _____.
   (a) preventing loss of insects–pests
   (b) preventing loss of diseases
   (c) preventing loss of moisture
   (d) All of the above
5. Short duration varieties of paddy must be transplanted during the _____.
   (a) first fortnight of July
   (b) second fortnight of July
   (c) first fortnight of August
   (d) second fortnight of August

C. Subjective Questions

1. Explain aberrant monsoon conditions.
2. Describe the types of aberrant monsoon.
3. Describe the effect of aberrant monsoon on crops.
4. Write a brief note on tackling aberrant weather conditions.
5. Differentiate between the following.
   (a) Early and terminal drought
   (b) Chronic and terminal drought

D. Match the Columns

A	B
1. Run-off	(a) Late season drought
2. Terminal drought	(b) By mulching
3. Apparent drought	(c) High intensity rainfall
4. Preventing moisture loss	(d) Medium to low rainfall regions

Unit 7

Maintaining Health and Safety Standards at the Workplace

171006CH07

Introduction

Occupational health relates to controlling health hazards that may arise while doing an agricultural work in a farm or laboratory. It deals with recognising, anticipating, evaluating and controlling such environmental factors at workplace, which may lead to health issues. Despite taking all precautions, accidents occur often while handling chemicals. Therefore, it is essential for students to know about the first aid measures that they need to take immediately, in case a chemical or mechanical accident occurs in a farm or lab. Besides, they need to learn about the safety measures that they may be required to follow in order to prevent such hazards.

Session 1: Preventing Hazardous Conditions at the Workplace

Hazard

It is a condition that has the potential to cause injury or sickness to human beings and animals, and adversely affect the environment. A hazardous substance can cause adverse health problems and physical damage at workplace. Fig. 7.1 shows the different types of hazard that may occur at the workplace.

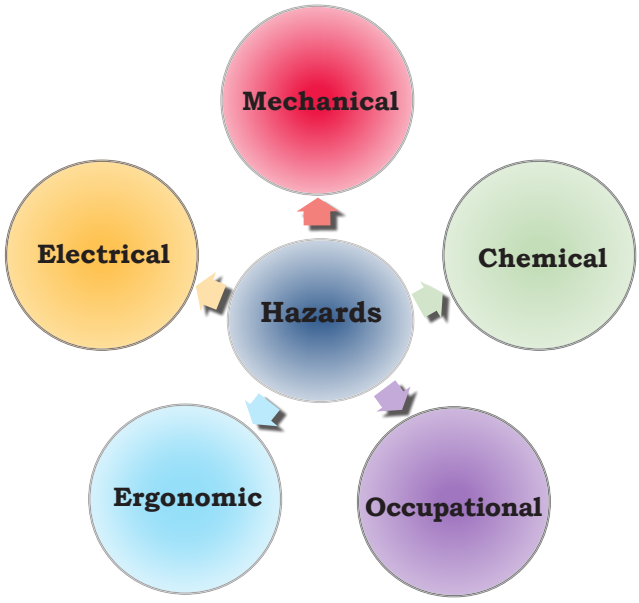


Fig. 7.1: Types of hazard

Mechanical hazards

These are related to poorly designed and ill-maintained agricultural machinery and equipment.

Chemical hazards

These comprise pesticide solutions meant for destroying, mitigating and controlling insects–pests. Accidental death from pesticides is a rarity but skin allergies or infections, and other health ailments may occur, if appropriate and timely precautions are not taken (Fig. 7.2). Careless handling or use of pesticides can cause harmful effects to the environment, handler and other living beings. Precautions must be taken while selecting a pesticide, its transportation, loading, mixing, application, storage and container disposal (Fig. 7.2, 7.3 and 7.4).

Fig. 7.2: Always wear personal protective equipment while preparing pesticide spray solutions

Fig. 7.3: Caution signage

Fig. 7.4: Signage indicating pesticide application in a field

Precautions

Toxicity labels marked on the pesticide package, as shown in Table 7.1 and Fig. 7.5, must be taken into account while using pesticides. Some of the points that must be taken care of prior to pesticide application are as follows.

- Chemicals must not be sprayed in foggy and windy weather conditions.
- A person spraying chemicals must not have an open injury or wound on the body.

Table 7.1: Toxicity label of pesticides

Name of the label	Level of toxicity	Listed chemicals
Red	Extremely toxic	Monocrotophos, Zinc phosphide, Ethyl mercury acetate, etc.
Yellow	Highly toxic	*Endosulfan*, *carbaryl*, *quinalphos*, etc.
Blue	Moderately toxic	*Malathion*, *thiram*, *glyphosate*, etc.
Green	Slightly toxic	*Mancozeb*, *oxyfluorfen*, mosquito repellant oils and liquids, and other household insecticides

Fig. 7.5: Colour labels showing the toxicity of pesticides

Occupational hazards

Farmers and workers, while working in an agricultural farm, may suffer from a number of occupational hazards. These hazards may include those related to farm machinery, biological and chemical substances, and stress. These may cause injuries, health disorders or diseases.

Hazards related to animals

Injuries inflicted by animals include bites, kicks, crushing and transmission of infectious diseases. If a farmer or person, working in a field, is injured by a farm

animal, immediate first aid must be administered to the person and timely medical treatment be provided. Injuries from cattle relate to a number of factors, including lack of trained workers, unsafe work practices, weight of the animal, stress, and sometimes, behaviour of the animal.

Ergonomic hazards

These are caused by inappropriate and cumbersome postures, leading to damage or pain in the muscles and tendons. These are mainly caused while working on or with inappropriate or faulty tools.

Electrical hazards

An electrical hazard arises due to faulty switches and machines, poor quality cords, overhead power lines, etc. Faulty electrical installations and use of cheap quality equipment can even cause fires (Fig. 7.6). When an equipment or machinery gets close to a high-tension line, it can lead to electric shocks, causing injury to the driver or the person handling it. In severe cases, it may even lead to electrocution, causing permanent disability or death of the person.

Fig. 7.6: Electricity hazard sign

Risk

This may be defined as the danger of loss from unforeseen situations. It is associated with a potential danger as regards to an activity. Understanding the kind of harm a machinery may cause to a farm worker or assessing the risk helps one design and implement strategic and operational plans for the mitigation of hazards. For example, the main hazard of a power-driven machine is of its getting trapped or entangled in power cables, ropes, etc. The following measures can help avert an accident in a farm.

- Identification of dangers in every aspect of a work
- Identification of people who may get exposed to some particular risks
- The reliability and adequacy of existing precautionary or preventive measures
- Decision on new measures that need to be introduced to eliminate or reduce risks

Practical Exercise

Activity

Make a flow chart on types of hazard, usually, witnessed at a workplace.

Material required: chart paper and writing material

Procedure

- Take a chart paper and draw a flow chart, depicting the different types of hazard, usually, witnessed at a workplace.
- Make a presentation in your class.
- Discuss the hazards that you have identified with your classmates and allow feedback on the topic.

Check Your Progress

A. Fill in the Blanks

1. A condition that has the potential to cause an injury to human beings and animals, and adversely affect the environment is known as a _____.
2. Substances intended for preventing and mitigating insects–pests are called _____.
3. If a farmer working in a field gets injured by a farm animal, then immediate _____ must be administered.
4. Risk is defined as the danger of loss from _____ situations.

B. Multiple Choice Questions

1. Ergonomic hazards are caused by _____.
   (a) inappropriate or faulty tools
   (b) machinery
   (c) chemicals
   (d) electricity
2. The use of dangerous substances comes under _____.
   (a) ergonomic hazards
   (b) extreme weather hazards
   (c) chemical hazards
   (d) natural hazards
3. Hazards caused due to agricultural machinery are called _____.
   (a) electrical
   (b) mechanical
   (c) chemical
   (d) None of the above
4. Electrical hazards arise due to _____.
   (a) faulty switches
   (b) spray chemicals
   (c) farm animals
   (d) All of the above

C. Subjective Questions

1. Define hazards.
2. List the various types of hazard related to agriculture and discuss them in brief.

D. Match the Columns

A	B
1. Green label	(a) Extremely toxic
2. Red label	(b) Highly toxic
3. Yellow label	(c) Moderately toxic
4. Blue label	(d) Slightly toxic

Session 2: First Aid, Treatment and Safety Equipment

Despite all precautions and care, accidents often take place while handling and applying chemicals. Therefore, it is important for students to know about the immediate medical aid that needs to be administered, in case of a chemical accident and learn about the safety and precautionary measures that need to be adopted in order to prevent them. Besides, they must learn about the Personal Protective Equipment (PPE) that they need to wear at all times while handling chemicals in order to be safe.

Chemical poisoning and first aid measures

Chemical poisoning may result from continuous contact with a chemical, absorption of a chemical through the skin, inhalation of toxic vapour or swallowing a chemical directly during handling or application. The common symptoms of pesticide poisoning are headache, vomiting, nausea, tremors, convulsion, difficulty in breathing, etc. A first aid kit with necessary antidotes must be made available at a workplace in order to treat all types of poisoning.

Fig. 7.7: First aid box

Personal Protective Equipment

Always wear Personal Protective Equipment (PPE) in order to prevent hazards due to pesticide poisioning. The various kinds of pesticide poisoning and their first aid treatment have already been discussed. PPE mainly consist of gas mask, gloves, shoes, eye shields, headgear, protective clothing, respiratory devices, etc. (Fig. 7.8 and 7.9).

Gas mask

It is used to protect the handler's eyes and respiratory tract from toxic gases and aerosols. It filters the air by removing contamination and impurities, and makes it fit for breathing or inhalation (Fig. 7.8).

Fig. 7.8: Hand gloves and gas mask

Gloves

Never use gloves made of leather, cotton or other fluid absorbant material while handling chemicals. Always use rubber gloves (Fig. 7.8).

Shoes

Shoes made of rubber or any other synthetic material must be used instead of leather or canvas ones.

Eye shields

These must be worn to prevent irritation and infection in the eyes due to gases and pesticides.

Protective clothing

An apron must be worn while working with treated crops or chemicals. The skin must be protected entirely. The clothing needs to be washed before re-use (Fig. 7.9).

Fig. 7.9: Protective clothing

General health and safety measures

- Identify what is unsafe or unhealthy.
- Take required action to solve unsafe or unhygienic issues at the workplace.
- Ensure that the problems are resolved and do not recur.
- Train workers on how to work safely.
- Design safe work procedures and supervise the workers.
- Provide a first aid kit and have personnel, who can administer first aid at the workplace.
- Arrange appropriate safety gear (for example, hats, gloves, reflective vests, etc.) for the workers.

Amenities and environment

- Ensure that the workers have access to civic utilities like toilets.
- They must have access to potable and clean drinking water.
- The worksite must have a first aid kit and workers, who can administer first aid in case of an accident or emergency.
- Ensure that the surrounding or building is safe. Look out for the presence of dangerous creatures (for example, snakes, spiders, scorpions, etc.) and reduce fire fuel loads.
- Provide a hand wash and face wash to the workers.

Emergency response

- The workers must be aware about the procedures that need to be followed in case of an emergency situation.
- Install emergency response equipment at the workplace.
- In case of an emergency, trained workers must be involved in administering first aid to patients.

Manual tasks

- Maintain appropriate restraint, wherever needed.
- Avoid crush injuries on hands.
- Pay attention to the risk of slips, trips and falls in yards.

Chemical and hazardous substances

- Safety Data Sheets (SDS) must be made available for all hazardous substances.
- Read the label and SDS carefully, and follow the instructions.
- Store the chemicals at a safe place and keep them away from ignition sources.
- Minimise exposure to the workers by adopting appropriate and recommended preventive measures and train them in safe handling techniques as regards to chemicals.
- Never store toxic chemicals in food and water containers. Always keep the chemicals in their original containers and make sure that they are labeled correctly with necessary instructions.

Electricity

- Keep all electrical equipment, appliances and naked power cables away from water and fire.
- Protect all electrical equipment with a residual current device (safety switch).
- Ensure that extension leads are not defective or damaged and are uncoiled when plugged into the main socket.
- It must be ensured that all electrical equipment and applicances are maintained and functional.

- All electrical equipment must be tested and tagged before use.
- Areas having overhead power cables must be identified with ground markers.
- Apply and mark appropriate exclusion zones while working near power lines.

Precautions to be taken in a farm

- While preparing a solution, one's face must never be just above the container, in which it is being prepared.
- While working with a chemical, one must always wear rubber gloves and face mask or shield to avoid direct physical contact with the chemical and check inhalation of chemical fumes.
- Clean the sprayer with a detergent immediately after spraying is completed.
- Follow the instructions mentioned on the pesticide bottle before using it.
- Take a bath and wash your clothes after spraying.
- Do not smell, taste or touch a chemical.
- Keep pesticides and other chemicals away from children's reach.

Practical Exercise

Activity

Demonstrate the use of Personal Protective Equipment while handling chemicals. Prepare a chart, depicting how you can use first aid to handle an emergency situation at the workplace.

Material required: chart paper, pictures of PPEs and first aid items, and writing material

Procedure

- Take a chart paper and paste the pictures of PPEs that one needs to wear while handling chemicals at the workplace.
- Label the PPEs and discuss the usage of each PPE item with your classmates.
- On another chart paper, paste the pictures of first aid items that you will use at the workplace.
- Label the first aid items and discuss the importance of each item with your classmates.
- Invite feedback from your classmates and ask if they can suggest some more precautionary measures while handling chemicals at the workplace.

NOTES

Check Your Progress

A. Fill in the Blanks

1. During pesticide spraying, _____ must be worn to prevent eye infections and irritation.
2. A gas mask is used to protect the eyes and respiratory tract from _____.
3. Gloves made of _____ must be used while handling chemicals.
4. While working with treated crops, _____ must be worn to protect the skin.

B. Multiple Choice Questions

1. Common symptoms of pesticide poisoning are _____.
   (a) headache
   (b) vomiting and nausea
   (c) difficulty in breathing
   (d) All of the above
2. To prevent hazards at workplace, the following material need to be put in place _____.
   (a) SDS
   (b) first aid kit
   (c) protective clothing
   (d) All of the above
3. Protective and safety equipment comprise _____.
   (a) gas mask
   (b) gloves
   (c) Both (a) and (b)
   (d) None of the above
4. Potentially dangerous creatures around house and office buildings include _____.
   (a) chameleon
   (b) snakes and scorpions
   (c) honey bees
   (d) All of the above

C. Subjective Questions

1. What are the first aid treatment measures that need to be adopted in case of chemical poisoning?
2. List the Personal Protective Equipment that one needs to wear while working in an agriculture field.

GLOSSARY

Acid soil: *soil with a pH of less than 7.*

Active ingredient: *chemicals present in a pesticide formulation, which are biologically active as toxins.*

Aerosol: *very fine droplets (0.125 µm in India) suspended in the air, generated by a container pressured with a gas propellant, or by aerosol generators, such as fogging machines or ultra-low volume equipment.*

Agriculture: *the art or science of cultivating crops, and the rearing and management of livestock.*

Alkaline soil: *soil with a pH of more than 7.*

Animal drugs: *drugs intended for use in the diagnosis, cure, mitigation, treatment or prevention of diseases in animals.*

Antibiotic: *a substance that can destroy or prevent the growth of bacteria and cure infections.*

Bacillus thuringiensis (Bt): *soil-inhabiting bacterium that reduces an insecticide effective against larval stages of many species of lepidoptera, although some strains are effective against beetle, mosquito and black fly larva.*

Bacterium (pl. bacteria): *microscopic, prokaryotic single-celled organisms having cell walls but lacking membrane-bound organelles.*

Bagging: *an activity of putting threshed grains in bags for transportation and storage.*

Biological control or biocontrol: *the practice, involving the introduction of predators, pathogens or parasites of pests.*

Botanicals: *pesticides derived from plants, such as pyrethrum, rotenone and nicotine.*

Bulb: *a modified stem that is the resting stage of certain seed plants, particularly, monocotyledons.*

Chemical control: *the reduction of pest population by the use of chemical pesticides.*

Crop residue: *the portion of a plant left in the field after harvesting. These can be used as straw material or byproducts.*

Crop rotation: *the practice of growing different crops in recurring succession on the same piece of land in contrast to monoculture cropping. This helps to spread the demand for nutrients by growing different crops each year, often in a four-year cycle.*

Cultural methods: *practices used to enhance crop and livestock health, and prevent weed, pest or disease problems without the use of chemical substances. Examples include the selection of appropriate varieties and planting sites; selection of appropriate breeds of livestock; providing livestock facilities, designed to meet the requirements of species or type of livestock; timing and density of plantings; irrigation, etc.*

First aid: *medical assistance given to a person or animal, suffering a sudden accident, illness or injury.*

Field drying: *the process of leaving the cut crop in a field and exposing it to the Sun for drying.*

Germplasm: *living genetic resources like seeds or tissues that are maintained for the purpose of animal and plant breeding, preservation and research purposes.*

Harvesting: *the process of collecting ripe crop from a field. An extended understanding of harvesting includes activities like reaping, stacking, handling, threshing, cleaning and hauling.*

Hauling: *transporting or carting the produce from a field to the desired location.*

Hazard: *any source of potential damage, harm or adverse health effects to a worker, animals and environment.*

Lamina: *the expanded portion or blade of a leaf. It is an over the ground organ in a plant specialised for photosynthesis.*

Lesion: *a damage or abnormal change in the tissue of an organism, usually, caused by a disease or trauma.*

Occupational hazards: *these comprise hazards at the workplace. There are other hazards like chemical, biological and physical as well that a person may encounter while working.*

Poison: *substance capable of causing illness or death.*

Reaping: *also called cutting, it is the physical removal of a crop from a field by cutting the whole plant. It can be done manually or mechanically.*

Rhizome: *also know as rootstock, it is a type of plant stem located either at the soil surface or underground, which contains nodes from where the roots emerge.*

Roots: *the organs in a plant that provide anchorage to the plant and transport water and nutrients to the plant body.*

Seed cleaning: *removing malformed, discoloured, germinated, broken or moldy grains from grains or seed lot.*

Stacking: *making an orderly pile or heap of a crop.*

Stem: *one of the two main structural axes of a vascular plant. It supports flowers, fruits and leaves, and transports water and nutrients between the roots and shoots.*

Stolon: *a creeping horizontal plant stem or runner that takes root at points along its length to form new plants.*

Suckers: *vigrous vertical growth emanating from the roots or lower main stem of a plant.*

Taproot system: *a large, central and dominant root from which other roots sprout laterally. This system has a single main root that grows downwards in direction.*

Threshing: *a part of the harvesting process, which involves separating grains from straws either by impact, friction or combing action.*

Tubers: *enlarged structures in some plant species used as storage organs for nutrients. They help in a plant's survival, and provide energy and nutrients for re-growth during the next growing season.*

Vermins: *wild animals or birds that destroy plants or food, or attack farm animals and poultry.*

Weedicides: *chemicals sprayed over the fields to get rid of weeds. Some of the popularly used weedicides are 2, 4-d ethylester, neem extract, glyphosote, etc.*

Winnowing: *removal of lighter material, such as unfilled grains, chaff, weed seeds and straws from grains with the help of a blower, air fan or wind. Winnowing retains only the heavier grains.*

Suggested Readings

Datta, S. K. D. 1981. *Principles and Practices of Rice Production*. John Wiley & Sons. New York.

Dhan ki Vaigyanik Kheti. 2016. Indian Council of Agricultural Research. Pusa. New Delhi.

Handbook of Agriculture. 2012. Indian Council of Agricultural Research. New Delhi.

Prasad, R. 2013. *Textbook of Field Crop Production*. Indian Council of Agricultural Research. New Delhi.

Reddy, Yellamanda and G.H. Sakara. 2015. *Principles of Agronomy*. Kalyani Publishers. Ludhiana, Punjab.

Singh, Chhidda. 1983. *Modern Techniques of Raising Field Crops*. Oxford and IBH Publishers. New Delhi.

Singh, S. S. 2017. *Crop Management under Irrigated and Rain-fed Conditions.* Kalyani Publishers. Ludhiana, Punjab.

Walia, U. S. and S. S. Walia 2015. *Crop Management.* Scientific Publishers. Jodhpur, Rajasthan.

Answer key

Unit 1: Weed Management in Paddy Crop

Session 1: Common Weeds in a Paddy Field and their Effects on Paddy Cultivation

A. Fill in the Blanks

1. weed
2. seeds and vegetative
3. critical
4. upland direct seeded
5. annuals

B. Multiple Choice Questions

1. (a) 2. (c) 3. (a) 4. (b)

D. Match the Columns

1. (b) 2. (e) 3. (d) 4. (a) 5. (c)

Session 2: Weed Management

A. Fill in the Blanks

1. pre-emergence
2. broad-leaved
3. herbicides
4. mechanical

B. Multiple Choice Questions

1. (c) 2. (b) 3. (a) 4. (c)

D. Match the Columns

1. (c) 2. (a) 3. (d) 4. (b)

Unit 2: Integrated Insect–pest and Disease Management in Paddy Crop

Session 1: Insect–pest Management in Paddy

A. Fill in the Blanks

1. crop rotation
2. summer
3. stem borer
4. leaf folder or leaf roller

B. Multiple Choice Questions

1. (c) 2. (b) 3. (b) 4. (c)

D. Match the Columns

1. (b) 2. (a) 3. (d) 4. (e) 5. (c)

Session 2: Disease Management in Paddy

A. Fill in the Blanks

1. bacterial leaf blight
2. sheath blight
3. bacterial leaf blight
4. panicles

B. Multiple Choice Questions

1. (a) 2. (c) 3. (c) 4. (a)

D. Match the Columns

1. (c) 2. (d) 3. (b) 4. (a)

Unit 3: Straw Management in Paddy

A. Fill in the Blanks

1. paddy straw
2. silica
3. *Tricoderma*
4. baling
5. baler

B. Multiple Choice Questions

1. (d) 2. (b) 3. (c)

D. Match the Columns

1. (d) 2. (a) 3. (b) 4. (c)

Unit 4: Harvesting and Storage

A. Fill in the Blanks

1. harvesting
2. golden yellow
3. threshing
4. 35
5. brown rice
6. spoilage
7. 9

B. Multiple Choice Questions

1. (d) 2. (d) 3. (b) 4. (b)
5. (b) 6. (d)

D. Match the Columns

1. (c) 2. (d) 3. (b) 4. (a) 5. (g)
6. (e) 7. (f)

Unit 5: Paddy Marketing

A. Fill in the Blanks

1. primary
2. fixed or stable
3. vary
4. marketing channels
5. government

B. Multiple Choice Questions

1. (a) 2. (a) 3. (b)

D. Match the Columns

1. (c) 2. (d) 3. (b) 4. (a)

Unit 6: Handling Emergency Situations during Paddy Crop Production

A. Fill in the Blanks

1. South-west
2. variable
3. early season
4. mid–season
5. arid

B. Multiple Choice Questions

1. (b) 2. (a) 3. (a) 4. (c) 5. (c)

D. Match the Columns

1. (c) 2. (a) 3. (d) 4. (b)

Unit 7: Maintaining Health and Safety Standards at the Workplace

Session 1: Preventing Hazardous Conditions at the Workplace

A. Fill in the Blanks

1. hazard
2. pesticides
3. first aid
4. unforeseen

B. Multiple Choice Questions

1. (a) 2. (c) 3. (b) 4. (a)

D. Match the Columns

1. (d) 2. (a) 3. (b) 4. (c)

Session 2: First Aid, Treatment and Safety Equipment

A. Fill in the Blanks

1. eye shields
2. toxic gases
3. rubber
4. protective clothing

B. Multiple Choice Questions

1. (d) 2. (d) 3. (c) 4. (b)

List of Credits

Unit 1: Weed Management in Paddy Crop

Fig. 1.1 : *Shama* or Jungle Rice (*Echinochloa colona*)
Courtesy: https://tinyurl.com/y62wyk9b

Fig. 1.2 : Marvel grass (*Dichanthium annulatum*)
Courtesy: https://tinyurl.com/yy4759cb

Fig. 1.3 : Swollen finger grass or peacock plume grass (*Chloris barbata*)
Courtesy: https://tinyurl.com/yxg67tbc

Fig. 1.4 : *Kutki* or blue panic grass (*Panicum spp.*)
Courtesy: https://tinyurl.com/y5h43vnu

Fig. 1.5 : *Doob* or bermuda grass (*Cynodon dactylon*)
Courtesy: https://tinyurl.com/y6bqmd3x

Fig. 1.6 : *Jungli mehendi* or blistering ammannia or *dadmari* (*Ammania baccifera*)
Courtesy: https://tinyurl.com/yy32pjkb

Fig. 1.7 : *Gokhula-kanta*: Gokshura (*Asteracantha longifolia*)
Courtesy: https://tinyurl.com/y4c498jp

Fig. 1.8 : *Nanka* or oval leaf pondweed (*Monochoria vaginalis*)
Courtesy: https://tinyurl.com/y24xptsp

Fig. 1.9 : Indian water navelwort or *brahmi*, (*Centella asiatica*)
Courtesy: https://tinyurl.com/y66jcwfn

Fig. 1.10 : *Kankawa* or Bengal dayflower (*Commelina benghalensis*)
Courtesy: https://tinyurl.com/yyunx6to

Fig. 1.11 : *Kana* or creeping cradle plant (*Cynotis axillaris*)
Courtesy: https://tinyurl.com/yy9w2teq

Fig. 1.12 : *Caupatiya* or *sunsuniya* or water clover (*Marselia quadrifolia*)
Courtesy: https://tinyurl.com/y4upqran

Fig. 1.13 : *Bhringaraj* or false daisy or *Karisalankanni* (*Eclipta prostrata*)
Courtesy: https://tinyurl.com/nogwddg

Fig. 1.14 : *Bhui aonla* (*Phyllanthes niruri*)
Courtesy: https://tinyurl.com/yyyyrv4g

Fig. 1.15 : *Bukkan* (*Phyla nodiflora*)
Courtesy: https://tinyurl.com/y4eqx9az

Fig. 1.16 : *Dudhi* (*Sonchus olaraceus*)
Courtesy: https://tinyurl.com/y6dpclaq

Fig. 1.17 : *Jalmukhi* (*Rotala densiflora*)
Courtesy: https://tinyurl.com/y2tze594

Fig. 1.18 : *Gul mundi* (*Sphaeranthus indicus*)
Courtesy: https://tinyurl.com/y2apb4n6

Fig. 1.19 : *Motha* (*Cyperus difformis*)
Courtesy: https://tinyurl.com/yy22m7ql

Fig. 1.20 : *Bara nagar motha* (*Cyperus rotundus*)
Courtesy: https://tinyurl.com/yy32pjkb

Unit 2: Integrated Insect–pest and Disease Management in Paddy Crop

Fig. 2.1 : Dead heart
Courtesy: Vijay Yadav, *Senior Rice Breeder*, CSAUAT, Kanpur, Uttar Pradesh.

Fig. 2.2 : White ear
Courtesy: Dinesh Kumar, *Principal Scientist* (*Agronomy*), Division of Agronomy, ICAR, New Delhi.

Fig. 2.3 : Egg of rice stem borer
Courtesy: Vijay Yadav, *Senior Rice Breeder*, CSAUAT, Kanpur, Uttar Pradesh.

Fig. 2.4 : Larva of rice stem borer
Courtesy: Vijay Yadav, *Senior Rice Breeder*, CSAUAT, Kanpur, Uttar Pradesh.

Fig. 2.5 : Adult *(moth)* of rice stem borer
Courtesy: Dinesh Kumar, *Principal Scientist* (*Agronomy*), Division of Agronomy, ICAR, New Delhi.

Fig. 2.6 : White and dried leaves
Courtesy: Dinesh Kumar, *Principal Scientist* (*Agronomy*), Division of Agronomy, ICAR, New Delhi.

Fig. 2.7 : Pupa of leaf folder or leaf roller
Courtesy: Dinesh Kumar, *Principal Scientist* (*Agronomy*), Division of Agronomy, ICAR, New Delhi.

Fig.2.8 : Adult leaf folder or leaf roller
Courtesy: Vijay Yadav, *Senior Rice Breeder*, CSAUAT, Kanpur, Uttar Pradesh.

Fig. 2.9 : Green leaf hopper
Courtesy: https://tinyurl.com/yxoo7zgo

Fig. 2.10 : Hopper burn in rice
Courtesy: Vijay Yadav, *Senior Rice Breeder*, CSAUAT, Kanpur, Uttar Pradesh.

Fig. 2.11 : Nymph of brown plant leaf hopper
Courtesy: Vijay Yadav, *Senior Rice Breeder*, CSAUAT, Kanpur, Uttar Pradesh.

Fig. 2.12 : Adult of brown plant leaf hopper
Courtesy: Vijay Yadav, *Senior Rice Breeder*, CSAUAT, Kanpur, Uttar Pradesh.

Fig. 2.13 : Rice mealybug nymph
Courtesy: Vijay Yadav, *Senior Rice Breeder*, CSAUAT, Kanpur, Uttar Pradesh.

Fig. 2.14 : Rice mealybug adult
Courtesy: Vijay Yadav, *Senior Rice Breeder*, CSAUAT, Kanpur, Uttar Pradesh.

Fig. 2.15 : Rice earhead bug (*Gundhi bug*)
Courtesy: Vijay Yadav, Senior Rice *Breeder*, CSAUAT, Kanpur, Uttar Pradesh.

Fig. 2.16 : Infected leaves of blast
Courtesy: Narendra Lakpale, *Professor*, Plant Pathology, IGKV, Raipur, Chhattisgarh.

Fig. 2.17 : Neck blast
Courtesy: Narendra Lakpale, *Professor*, Plant Pathology, IGKV, Raipur, Chhattisgarh.
Fig. 2.18 : Bacterial leaf blight
Courtesy: Narendra Lakpale, *Professor*, Plant Pathology, IGKV, Raipur, Chhattisgarh.
Fig. 2.19 : Rice tungro disease or rice tungro virus (RTSV, RTBV
Courtesy: https://bit.ly/2k6ZN26
Courtesy: https://bit.ly/2m61tJV
Fig. 2.20 : Different symptoms of rice sheath blight
Courtesy: Narendra Lakpale, *Professor*, Plant Pathology, IGKV, Raipur, Chhattisgarh.
Fig. 2.21 : Symptoms of rice sheath rot
Courtesy: Narendra Lakpale, *Professor*, Plant Pathology, IGKV, Raipur, Chhattisgarh.
Fig. 2.22 : Symptoms of rice brown
Courtesy: Vijay Yadav, *Senior Rice Breeder*, CSAUAT, Kanpur, Uttar Pradesh.
Fig. 2.23 : Symptoms of rice false smut
Courtesy: Vijay Yadav, *Senior Rice Breeder*, CSAUAT, Kanpur, Uttar Pradesh.

Unit 3: Straw Management in Paddy

Fig. 3.1 : Bailing of rice straw
Courtesy: https://tinyurl.com/y63j37sf
Fig. 3.2 : Paddy straw as a packing material
Courtesy: https://bit.ly/2lUU3ZR
Fig. 3.3 : Paddy straw — rope
Courtesy: https://bit.ly/2md0OX0

Unit 4: Harvesting and Storage

Fig. 4.1 : Stage of harvesting
Courtesy: Dinesh Kumar, *Principal Scientist* (*Agronomy*), Division of Agronomy, ICAR, New Delhi.
Fig. 4.2 (a to e) : Paddy manual harvesting
Courtesy: Dinesh Kumar, *Principal Scientist* (*Agronomy*), Division of Agronomy, ICAR, New Delhi.
Fig. 4.3 : Manual threshing
Courtesy: Dinesh Kumar, *Principal Scientist* (*Agronomy*), Division of Agronomy, ICAR, New Delhi.
Fig. 4.4 : Manual paddy thresher
Courtesy: Dinesh Kumar, *Principal Scientist* (*Agronomy*), Division of Agronomy, ICAR, New Delhi.
Fig. 4.5 : Power operated paddy thresher
Courtesy: Dinesh Kumar, *Principal Scientist* (*Agronomy*), Division of Agronomy, ICAR, New Delhi.
Fig. 4.6 : Combine harvesting machine
Courtesy: https://bit.ly/2YH9S4t

Unit 7: Maintaining Health and Safety Standards at the Workplace

Fig.7.1 : Types of hazard
Fig.7.2 : Safety apparel for preparing spray solutions
Courtesy: https://goo.gl/ygxajB
Fig.7.3 : Caution signages while pesticide spraying
Courtesy: https://goo.gl/uixDC7
Fig.7.4 : Signage for pesticide application in a field
Courtesy: https://goo.gl/XzFfqn
Fig.7.5 : Labels of colours showing toxicity of pesticide
Courtesy: https://goo.gl/nWpfBV
Fig.7.6 : Electricity hazard sign
Courtesy: https://goo.gl/nUK73m
Fig.7.7 : First aid box
Courtesy: https://goo.gl/BLyejx
Fig.7.8 : Hand gloves and mask
Courtesy: https://goo.gl/ZvGFsn
Fig.7.9 : Protective clothing
Courtesy: https://goo.gl/mzBA2Q