UNIT 1 PRODUCTION, MORPHOLOGY, COMPOSITION AND UTILIZATION

Structure

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1.0 OBJECTIVES

After reading this unit, you should be able to:

• explain morphological structure of rice;
• state agronomical package of practices for rice production in different rice-ecosystems;
• know composition and properties of rice; and
• gain knowledge on product and by-product utilization.

1.1 INTRODUCTION

Rice is the world’s most important food crop and a primary source of food for more than half the world population. More than 90 percent of the world’s rice is grown and consumed in Asia. Rice accounts for 35 to 75 percent of the calories consumed by more than 3 billion Asians.

The world’s capacity to sustain a favourable food production/population balance has come under threat in view of continued population increase and a drastic slowdown in the growth of cereal production (Brown, 1996). Rice production increased at a rate of 2.5 to 3.0 percent per year during the 1970s and 1980s. However, during the 1990s, the growth rate was only 1.5 percent. According to United Nations estimates, the world population will grow up to 8 billion in 2025. Most of this increase (93 percent) will occur in developing countries, whose share of population is projected to increase from 78 percent in the 1990s to 83 percent in 2020.
Scientific achievements in increasing yields have been fast and profound in Asia's intensive rice systems, but farmers' knowledge and corresponding practices are not in pace, particularly in agronomical management practices and utilization of rice. Efficient resource management and agro-technology can be used to improve farmers' management practices in order to enhance profitability and develop high-productivity systems in rice.

### 1.2 MORPHOLOGICAL STRUCTURE

The rice plant (Oryza sativa L.) is a member of Gramineae family. The common cultivated plant is an annual which usually grows to a height of half a metre to two metres. Rice plant can be divided into two main parts; (i) root system and (ii) shoot system.

(i) Root system: When a rice grain germinates, coleoptile and coleorhiza emerge. The primary embryonic root (radicle) comes out through the coleorhiza shortly after it appears. This is followed by two or more secondary roots, all of which develop lateral roots.

(ii) Shoot system: This is the plant parts above the ground level. It is mainly composed of culms, leaves and panicle.

   a. Culm: The culm or stem is made up of series of nodes and internodes. The culm is usually hollow, except at nodes. Each node bears a leaf and a bud.

   b. Leaves: Leaves are borne at an angle on the culm in two ranks along the stem, one at each node. The leaf blade is attached to the node by the leaf sheath.

   c. Panicle: Rice inflorescence is known as panicle is a group of spikelets borne on the uppermost node of the stem. The primary panicle branch is divided into secondary and tertiary branches.

   d. Spikelet: The spikelet consists of hard covering of two sections of which are known as lemma and palea. The lemma and palea together known as hull. The matured spikelet is called grain.

Grain: Rice grain is a caryopsis in which the single seed is fused with the wall of ripened ovary. In general, rice grain consists of hull and bran coat as outer most portion and endosperm and embryo as innermost portion (Fig. 1.1). The hull and a bran coat are removed on polishing as white rice. The endosperm consists of aleurone layer which is rich in phosphorus, magnesium and potassium (Tanaka et al., 1974). The embryo contains embryonic leaves (plumule) and embryonic primary roots (radicle), which are joined by a very short stem (mesocotyl). The plumule is enclosed by a protective covering, the coleoptile and the radicle is ensheathed by a mass of soft tissue, the coleorhiza.

### 1.3 AGRONOMICAL PRACTICES

Rice is mainly grown in India during June to November, known as ‘kharif’ or wet season and during December to April, known as ‘rabi’ or dry season. Kharif rice is grown under either rainfed or irrigated condition, whereas rabi rice requires assured irrigation. The
best soil suited for rice is clay-loam to clay. It grows well in soils having pH range 5.5 to 6.5 and has adaptability to pH in range 4.5 to 7.5. Being a semi-aquatic plant, rice grows best under submerged condition. According to water regime, rice ecosystem have been classified as (i) Upland (no standing water), (ii) Lowland (5-50 cm standing water), and (iii) Deep water (>51 cm standing water). Figure 1.2 shows world’s rice land classification by water regime and rice types. A major part of rice crop in India is grown under lowland condition.

![Figure 1.2: Classification of world's rice land by water regime and predominant rice types](image)

Varietals requirement and agronomic package of practices which vary with the land situations are as follows:

**Varietals requirement**: Photoinsensitive varieties are grown under upland condition. Both photo-sensitive and insensitive varieties are grown under lowland condition. Where under deep water condition, only photosensitive varieties are grown.

**Upland ecosystem**:
- Semidwarf to intermediate height (< 100 cm)
- Early maturing (90-100 days)
- Medium to heavy tillering
- Tolerance for recovery from moderate drought stress
- Resistance to blast and bacterial leaf blight

**Lowland ecosystem**:
- Medium tall in height (100-130 cm)
- Medium to long duration (120-150 days)
- Moderate elongating capacity
- Tolerance to Submergence
- Resistance to lodging

**Deep water ecosystem**:
- Good seedling vigour
- Ability to elongate with rise in water level
- Tolerance to Submergence
Kneeling ability is required if elongation takes place as plants lodge when water recedes. Photoperiod sensitivity should assure flowering when plants are least vulnerable to submergence.

**Production practices**

Upland and lowland rice ecosystem accounts 90% of total rice area in India. So production practices for these land situations are discussed.

*Upland ecosystem:*

Field preparation: After harvest of rabi season crop, the field should be ploughed with soil turning plough. This will be helpful in weed eradication and improvement in soil water holding capacity. The field should be well prepared and bund should be raised around to hold water.

Seed sowing: Seeds are shown behind plough or drilled with seed drill. The row spacing should be maintained 15 - 30 cm. Seed rate is 40 - 60 kg per hectare.

Fertilizer management: Adequate and timely supply of nutrients is a prerequisite for realising optimum yield. On an average, rice crop removes 20-22 kg N, 5-6 kg P and 25-30 kg K per hectare from soil along with few gram of micronutrients. A fertilizer dose of 60-80 kg N, 30-40 kg P\(\text{O}_3\) and 30-40 kg K\(\text{O}\) is recommended. Full amount of the fertilizer P and K should be applied at the time of land preparation as basal dose. The fertilizer N should be applied in three equal splits at basal, tillering (35 – 40 days after sowing) and panicle initiation stage. The best timing of fertilizer application is shown in Fig.1.3.

Weeding and hoeing: In upland rice weeds cause considerable reduction in yield/production and quality of produce. Hence, timely control of weed is important. Two hand weeding at 25-30 days after soil along with some DAS and 60-65 DAS is recommended as manual weed control. Through chemical method of weed control, Benthiocarb (Saturn) @ 2 kg /ha should be applied six to seven days after seeding rice. It should be followed by one manual weeding 40-45 days after sowing. Major weeds that normally infest rice crop are:

*Echinochloa colonum, Echinochloa crusgalli, panicum sp., Setaria glauca, Cyperus rotundus, Cyperus deformis, Digitaria sp., etc.*

Disease and pest control: Disease and pest on an average cause about 10% reduction in yield, which may go from 50 to 90% in severe cases. Suitable control measure for major diseases and pests are provided in Table 1.1.
<table>
<thead>
<tr>
<th>Diseases/pests</th>
<th>Symptom</th>
<th>Control measure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diseases</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blast</td>
<td>Boat or eye shaped spots with gray or dark brown margin appear on the leaf and leaf sheaths. In severe cases the spots may coalesce and form large blighted spots.</td>
<td>Seed treatment with Thiram @ 2.5 g/kg seed                          Spray the crop with 0.1% Hinosan 50 EC</td>
</tr>
<tr>
<td>Brown spot</td>
<td>On the leaves circular or oval dark brown to purplish brown spots are found. Black spots appear on grain</td>
<td>Seed treatment with Thiram @ 2.5 g/kg seed. Add murate of potash to correct potash deficiency in soil 3-4 sprays of Dithane M-45 @ 0.25% at an interval of 10-12 days</td>
</tr>
<tr>
<td>Bacterial leaf blight</td>
<td>The blighting starts from tip of leaves from one or both the margins or in the centre and proceeds downward. The leaves turn straw yellow. Grains are partially filled or become chaffy.</td>
<td>Drain standing water from time to time Use balanced fertilizer dose 3-4 sprays of mixture of 75 g Agrimycin-100 and 500 g copper oxychloride in 500 litre of water per hectare</td>
</tr>
<tr>
<td>Khaira</td>
<td>This usually appears in nursery. Growth of plant stunted. Chlorosis appear between veins of leaves, where brown spots are found.</td>
<td>2 Sprays of 5 kg Zinc sulphate and 2.5 kg lime in 1000 litres of water per hectare in nursery</td>
</tr>
<tr>
<td><strong>Pests</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stem borer</td>
<td>They bore and feed inside the stem that results in ‘dead heart’ and ‘white head’.</td>
<td>Apply Furadan 3G @ 30-33 kg/ha or Thimet 10G @ 10 kg/ha in 3-4 cm standing water.</td>
</tr>
<tr>
<td>Gall midge</td>
<td>Regular tillers are transformed into tubular galls, resembling the leaf of onion.</td>
<td>Same as of stem borer</td>
</tr>
<tr>
<td>Rice hispa</td>
<td>They scrap on upper surface of leaf blade, leaving only lower epidermis. Damaged area show white streaks</td>
<td>Spray Dimecron 100 EC @ 0.5 ml/litre of water</td>
</tr>
<tr>
<td>Leaf roller</td>
<td>Leaf blades are folded onto tubular structure and larvae of the insect feed within this portion of leaf causing white streaks.</td>
<td>Spray Ekalux 25 EC @ 2 ml/litre of water</td>
</tr>
<tr>
<td>Gandhi bug</td>
<td>They cause damage by sucking the plant sap and particularly milky juice of the developing grains</td>
<td>Apply Aldrin @ 20-25 kg/ha</td>
</tr>
</tbody>
</table>
Harvesting: Timely harvest ensures good yield and quality and consumer acceptance because of less breakage while milling. The right stage of harvesting is 25 – 35 day after flowering, when about 80% panicles have about 80% ripened spikelets. In general rice should be harvested at 18-22% moisture content or when grains on lower part of the panicle are in hard dough stage.

Rice plant is cut with a sickle leaving 10-15 cm stubble and dried in the field for 2-3 days or carried away from main field to threshing yard. Combine harvester is used in developed countries, where agriculture is fully mechanized.

Postharvest measure: The postharvest measures are threshing, cleaning, drying, storage, processing and milling. Threshing is the method of separating grain from panicle by hand beating or by mechanical thresher. Cleaning is removal of foreign seeds, rubbish and stones from rice grain. Cleaning is mostly done by hand winnowers taking advantage of wind. The other common cleaning methods are air cleaning with high air velocity and mechanical cleaning with sieves. Cleaning improves storability and milling quality of rice. Moisture content of freshly harvested rice grain should be reduced to 14% through drying for prolonged storage. Rice grain is stored in sacks, metal or wooden boxes, bamboo baskets, cans, drums, and small granaries. The materials used for storing should keep the grain dry, cool and pest free. The storage condition affects processing and milling quality of rice.

Lowland ecosystem:

This system of rice rarely suffers from water stress. In this system, rice is grown either as transplanting or direct seeding method. Details of the methods are as follows:

Transplanting:

In this method rice seeds are shown in a nursery bed under well managed condition. The seedlings after attaining shorten age (20-30 days) are transplanted in main field. The details on nursery raising and transplanting are explained.

Raising nursery: An area of about 500 m$^2$ is required for raising nursery to transplant one hectare main field. The nursery area should be fertile, well drained and upland field with assured irrigation. About 50 kg of viable, clean and true-to-the-variety seeds with high germination percentage (>80%) are recommended for one hectare main filed. The seeds should be pre-germinated by soaking with water followed by incubation. Seeds are generally soaked in fresh water for 24 hours. Thereafter they should be placed in a clean and moist bag folded tightly and kept in shade for incubation. The incubation period of 24-36 hours is required for sprouting. The sprouted seeds are used for nursery sowing. There are three main methods of raising nursery; i.e., wet bed, dry bed and dapog (soil less nursery).

(a) Wet bed: Wet nurseries are preferred under irrigated condition. Soil is well puddled, leveled and bunded nursery beds of 1.25 m width and of any convenient length. Drainage channel of 30 cm is provided to facilitate sowing, weeding, spraying of chemicals and irrigation. Each bed of 10 m$^2$ is normally fertilized with 225 g of urea and 500 g of single super phosphate. Seeds are broadcasted uniformly in all the beds. The beds should be kept saturated with water for the first five days and then water level may be increased gradually up to 5 cm as the seedlings grow. The seedlings become ready for transplanting in about 20-25 days.

(b) Dry bed: This method is practiced in areas where water is not sufficient to grow seedlings in wet nursery. Soil should be well pulverized and raised (about 15 cm) beds of same size as that of wet nursery. The seeds are sown in rows of 10 cm apart in dry or moist condition and covered with a thin layer of soil. The beds are saturated with water and flooding is avoided. All other operations remain same as that of wet bed nursery.
Dapog: This method saves area as well as time in seedling rising. An area of 25-30 m² is enough to raise seedlings sufficiently for one hectare planting. Beds are prepared on an even but slightly raised (4-5 cm) surface in an open leveled and compacted field or on a cement floor covered with polythene sheets. About 1 m² bed is sown with 2-3 kg seeds. Pre-germinated seeds spread uniformly in thin layers of 2-3 seeds thickness over plastic or banana leaves. Seeds are to be packed to avoid displacement. Water to be sprinkled 3-4 times a day to keep the bed moist. Dapog nursery seedlings are ready for transplanting within 11-14 days of sowing. The seedlings thus raised can be rolled like a mat or carpet with roots facing outside and transported to transplanting site.

Field preparation: The soils of rainfed lowlands have varying texture like loam, clay loam and heavy clay. The heavier textured soils pose some problem in tillage and land preparation for getting the desired soil tilth before sowing. So, the land should be ploughed immediately after the harvest of the previous crop, preferably with a mould board plough that breaks hard pan and keep the soil loose. This facilitates sowing and other operations to be completed in time. Soon after pre-monsoon showers, one or two summer ploughings in April-May can keep the land ready for timely operation. The method of land preparation for transplanted rice is puddling the soil. Puddling causes physical destruction of soil aggregation and non-capillary pore space as a result of which the individual soil particles get segregated and dispersed leaving the soil mass into a soft puddle (Satiko and Kawaguchi, 1971). Soil bulk density is increased and porosity is decreased due to puddling which reduce deep percolation of water because reduction in hydraulic conductivity.

Transplanting: Seedlings of 20-25 days old or at 4-5 leaf stage in nursery were used for transplanting in main field. They are transplanted at 2-3 seedlings per hill with a row spacing of 15-25 cm and plant spacing of 10-20 cm. The depth of transplanting should be maintained as 2-3 cm in soil. The advantages of transplanted rice are:

- It helps maintaining optimum plant population at desired spacing in the field. Thus facilitates uniform and healthy crop stand and equal opportunity to utilize land space, light, nutrients and water.
- Weeds are substantially killed in the process of puddling and subsequent submergence.

Direct seeding

In this method seeds are directly broadcasted or dibbled into soil behind country plough or drilled in lines with seed drill in the main field, where it grows up to maturity. In general seed rate of 40 – 50 kg per hectare required for drilling and 80-100 kg/ha for broadcasting. There are mainly two types of direct seeding. They are (a) dry seeding and (b) wet seeding.

Dry seeding: In this method seeds are sown directly in a well ploughed soil following receipt of premonsoon shower. After sowing, the seeds are covered in soil by running a light harrow or wooden plank. The seeds germinate with the available soil moisture or with the rains after seeding. Time of seeding is the most crucial factor in determining initial crop stand and yield. Studies at Central Rice Research Institute, Cuttack, indicated that sowing of rice in the first half of June (5-15) produce highest yield and that beyond 25 June reduces yield significantly (Mishra, 1999).

Wet seeding: In this method sprouted seeds are sown into the puddle soil. This method of seeding has been claimed as an economically viable alternative to transplanting method provided perfect land leveling and control over irrigation/rain water should be ensured.

Beushening is a common practice in direct seeded lowland rice in Orissa, Madhya Pradesh, Bihar, and to a lesser extent in West Bengal, Assam and Uttar Pradesh to control weeds,
optimize crop stand and to improve soil aeration. It involves cross ploughing the young rice crop at 4-6 weeks after seeding in about 5-10 cm standing water with a light country plough once or twice depending upon weed density and crop stand. Due to this operation, the crop is weeded, thinned and gaps are filled with uprooted seedlings.

Manure and fertilizer: Application of bulky organic manure is desirable to maintain and improve soil physico-chemical and biological properties. Farm yard manure or compost @ 10-15 t/ha should be applied to the main field at 4-6 weeks before sowing/transplanting of rice.

Application of chemical fertilizer depends upon fertility status of soil, previous crop grown and amount of organic matter added. A general recommended dose 100 kg N, 50 kg P\textsubscript{2}O\textsubscript{5} and 50 kg K\textsubscript{2}O per hectare may be followed. Full dose of P and K and half dose of N may be incorporated into soil as basal application before last puddling. Rest amount of N should be applied as top dressing in two equal splits, first at tillering stage and the second at panicle initiation stage.

Methods of application of N fertilizer are crucial in rice as most of applied N (60-70\%) is lost through leaching and denitrification. Some techniques developed to minimise the loss are:

i) Use of pre-incubated urea: Urea is mixed with moist soil at the ratio 1:5. The mixture should be kept in shade for 36-48 hours before application.

ii) Use of mud ball: Small ball of moist soil is prepared and urea is put in the centre of ball. The opening is closed and it is allowed to dry little. These balls are used in paddy field under standing water.

iii) Use of neemseed cake: Finely ground neem seed cake is mixed with urea @ 15-20\% for application to rice. This cake delay nitrate formation from urea and thus reduce the possibility of nitrate loss through denitrification or leaching.

Water management: Water requirement of rice is higher than any other crop of similar duration and varies from 150 – 250 cm. There are some critical stages in rice where water requirement is very high. The water requirement is high during initial seedling period covering about 10 days. Tillering to flowering is the most critical stages, when the crop should not suffer from water stress. Ensure enough water from panicle initiation to flowering. The critical stages in order of decreasing importance of water requirement are flowering, grain filling, tillering, panicle initiation and transplanting. Application of small quantities of water at short interval to keep the soil saturated is more effective and economical than flooding at long interval. However flooding suppresses weed growth and increases availability many nutrients, particularly phosphorus, potassium, calcium, iron and silica.

Disease and pest and weed control, harvest and postharvest measures are same as of upland rice.

Check Your Progress 1

Note: a) Use the space below for your answer.

b) Compare your answers with those given at the end of the unit.

1. Describe morphological structure of rice grain
2. What are rice ecosystems?

3. Explain the quickest methods of raising rice nursery?

4. Describe efficient nitrogen management in lowland rice ecosystem.

5. What are the symptoms of rice blast disease and specify the control measure?

6. What is beushening and how is it important for rice production under lowland ecosystem?

1.4 PRODUCTION STATISTICS AND ACREAGE

Rice area, production and yield in India in five years interval since 1965 are given in Table 1.2. It shows that rice acreage and production has increased from 35470 thousand hectare and 45884 thousand tones in the year 1965 to 44712 thousand hectare and 127400 thousand tones during 2000, respectively. The increase in acreage covered by rice is only 26%, whereas the increase in production of 178%, is due to accelerated increase in yield from 1.29 t/ha in 1965 to 2.85 t/ha in 2000. After the year 2000, rice area and production has decreased marginally, however the yield continues to increase.

Table 1.2: Rice acreage, production, and yield in 5 years interval in India

<table>
<thead>
<tr>
<th>Year</th>
<th>Acreage (000 ha)</th>
<th>Production (000 t)</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>35470</td>
<td>45884</td>
<td>1.29</td>
</tr>
<tr>
<td>1970</td>
<td>37592</td>
<td>63338</td>
<td>1.68</td>
</tr>
<tr>
<td>1975</td>
<td>39475</td>
<td>73352</td>
<td>1.86</td>
</tr>
<tr>
<td>1980</td>
<td>40152</td>
<td>80312</td>
<td>2.00</td>
</tr>
<tr>
<td>1985</td>
<td>41137</td>
<td>95818</td>
<td>2.33</td>
</tr>
<tr>
<td>1990</td>
<td>42687</td>
<td>111517</td>
<td>2.61</td>
</tr>
<tr>
<td>1995</td>
<td>42800</td>
<td>115440</td>
<td>2.70</td>
</tr>
<tr>
<td>2000</td>
<td>44712</td>
<td>127400</td>
<td>2.85</td>
</tr>
<tr>
<td>2004-05</td>
<td>42500</td>
<td>124400</td>
<td>2.93</td>
</tr>
</tbody>
</table>

Source: http://www.irri.org/science/ricestat/
1.5 WORLD AND INDIAN TRADE

Rice acreage, production, and yield in 10 years interval in India as compared to world and Asia figure is shown in table 1.3. India rice production has been increased by 100% from the year 1970 to 2000 and that of world and Asia is near to 90%. Rice calorie supply as percentage of total calorie in world is about 20%, whereas in India is > 30% (Table 1.4).

Table 1.3: Rice acreage, production, and yield in World, Asia and India

<table>
<thead>
<tr>
<th>Year</th>
<th>World Acreage (000 ha)</th>
<th>World Prod (000 t)</th>
<th>World Yield (t/ha)</th>
<th>Asia Acreage (000 ha)</th>
<th>Asia Prod (000 t)</th>
<th>Asia Yield (t/ha)</th>
<th>India Acreage (000 ha)</th>
<th>India Prod (000 t)</th>
<th>India Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>133098</td>
<td>316384</td>
<td>2.38</td>
<td>120919</td>
<td>290101</td>
<td>2.40</td>
<td>37592</td>
<td>63338</td>
<td>1.68</td>
</tr>
<tr>
<td>1980</td>
<td>144664</td>
<td>396873</td>
<td>2.74</td>
<td>128995</td>
<td>360105</td>
<td>2.79</td>
<td>40152</td>
<td>80312</td>
<td>2.00</td>
</tr>
<tr>
<td>1990</td>
<td>146976</td>
<td>518221</td>
<td>3.53</td>
<td>132440</td>
<td>477697</td>
<td>3.61</td>
<td>42687</td>
<td>111517</td>
<td>2.61</td>
</tr>
<tr>
<td>2000</td>
<td>154121</td>
<td>598983</td>
<td>3.89</td>
<td>138141</td>
<td>545379</td>
<td>3.95</td>
<td>44712</td>
<td>127400</td>
<td>2.85</td>
</tr>
</tbody>
</table>

Table 1.4: Rice calorie supply as percentage of total calorie supply in world, Asia and India, during 1970-2000

<table>
<thead>
<tr>
<th>Year</th>
<th>World</th>
<th>Asia</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>20</td>
<td>38</td>
<td>32</td>
</tr>
<tr>
<td>1980</td>
<td>20</td>
<td>36</td>
<td>30</td>
</tr>
<tr>
<td>1990</td>
<td>21</td>
<td>35</td>
<td>33</td>
</tr>
<tr>
<td>2000</td>
<td>20</td>
<td>31</td>
<td>30</td>
</tr>
</tbody>
</table>

1.6 RICE COMPOSITION

Rice is primarily a high-calorie food. The protein content of milled rice is 6 – 7%, which has high biological value, being 96.5% of whole kernel and 98% of milled rice. Rice is compared favorably with other cereals in amino acids content. The fat content of rice is low (around 2.0%) and much of the fat is lost during milling. The nutritional composition of rice is shown in table 1.5.

Table 1.5: Composition of brown and white rice (Reddy, 2006)

<table>
<thead>
<tr>
<th>Contents</th>
<th>Brown rice (whole kernel)</th>
<th>White rice (milled rice)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture, %</td>
<td>12.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Kcal per 100g</td>
<td>360.0</td>
<td>363.0</td>
</tr>
<tr>
<td>Protein, %</td>
<td>7.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Fat, %</td>
<td>2.0</td>
<td>0.4</td>
</tr>
<tr>
<td>Ash, %</td>
<td>1.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Carbohydrates, %</td>
<td>77.4</td>
<td>80.4</td>
</tr>
<tr>
<td>Fibre, %</td>
<td>0.9</td>
<td>0.3</td>
</tr>
<tr>
<td>Calcium, mg 100 g⁻¹</td>
<td>32.0</td>
<td>24.0</td>
</tr>
<tr>
<td>Phosphorus, mg 100 g⁻¹</td>
<td>221.0</td>
<td>94.0</td>
</tr>
<tr>
<td>Iron, mg 100 g⁻¹</td>
<td>1.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Sodium, mg 100 g⁻¹</td>
<td>9.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Potassium, mg 100 g⁻¹</td>
<td>214.0</td>
<td>92.0</td>
</tr>
<tr>
<td>Thiamin, mg 100 g⁻¹</td>
<td>0.34</td>
<td>0.07</td>
</tr>
<tr>
<td>Riboflavin, mg 100 g⁻¹</td>
<td>0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>Niacin, mg 100 g⁻¹</td>
<td>4.7</td>
<td>1.6</td>
</tr>
</tbody>
</table>
The by-products of rice milling are bran and hull. Rice bran is used as cattle feed or poultry feed. Rice hulls are used in manufacture of insulation material, cement and cardboard and also used as litter in poultry keeping.

1.7 PHYSICAL AND MECHANICAL PROPERTIES OF RICE

The dimension of the rice grain and milled rice kernel play an important role in the determination of grain standards throughout the processing cycle. This grain dimension is classified according to or in relation to the following.

The type of rice-classified according to the length of the whole brown rice grain.

a) Extra long: Eighty percent of the whole brown rice kernels having a length of 7.5 mm. or more.

b) Long: Eighty percent of the whole brown rice kernels having a length of 6.5 mm. or more but shorter than 7.5 mm.

c) Medium: Eighty percent of the whole brown rice kernels with a length between 5.5 mm. to 6.5 mm.

d) Short: Eighty percent of the whole brown rice kernels are shorter than 5.5 mm.

Check Your Progress 2

Note: a) Use space given below for your answers.
b) Check your answers with those given at the end of the unit.

1. State the rice production scenario of India and world

2. Explain nutritional composition of rice

3. Describe the utilization of by-product of rice milling

1.8 LET US SUM UP

Rice is the major food grain of India that contributes more than 30% of the calorie supplies. The carbohydrate content in rice is about 80%. Rice is grown mainly in wet season (June-December) under diverse ecosystems as direct seeded for areas of limited water availability and as transplanted with assured water. The agronomic practices in rice production are nursery raising, land preparation, seeding/transplanting, manure and fertilizer management, weeding, water management, intercultural operations, insect pest
and disease control, and harvesting. Selection of variety suitable to an ecosystem with appropriate agronomic management practice can ensure optimum rice yield.

The by-products of rice milling are bran used as cattle feed or poultry feed, and hull used as input for manufacture of insulation material, cement, and cardboard.

1.9 KEY WORDS

<table>
<thead>
<tr>
<th><strong>Rice grain</strong></th>
<th>Rice grain is a caryopsis in which the single seed is fused with the wall of ripened ovary. Rice grain consists of hull and bran coat as outermost portion and endosperm and embryo as innermost portion.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rice ecosystem</strong></td>
<td>The environment in which rice is grown is called rice ecosystem. According to water regime, rice ecosystem has been classified as upland, lowland and deep water rice.</td>
</tr>
<tr>
<td><strong>Dapog nursery</strong></td>
<td>The method of raising rice nursery without soil. This method saves area as well as time in seedling rising.</td>
</tr>
<tr>
<td><strong>Puddling</strong></td>
<td>Puddling is the method of land preparation for transplanted rice. Puddling causes physical destruction of soil aggregation and non-capillary pore space and reduces deep percolation of water.</td>
</tr>
<tr>
<td><strong>Direct seeding</strong></td>
<td>Rice seeds are directly broadcasted or dibbled into soil behind country plough or drilled in lines with seed drill in the main field called direct seeding.</td>
</tr>
<tr>
<td><strong>Transplanting</strong></td>
<td>Rice seedlings of 20-25 days old or at 4-5 leaf stage are planted in the main field is known as transplanting.</td>
</tr>
<tr>
<td><strong>Beushening</strong></td>
<td>Beushening is a common intercultural practice in direct seeded lowland rice to remove weeds and fill the gaps in plant population by cross ploughing the young rice crop at 4-6 weeks after seeding in about 5-10 cm standing water.</td>
</tr>
<tr>
<td><strong>Fertilizer Management</strong></td>
<td>Timely, required amount and right form of nutrient supply to the crop is known as fertilizer management.</td>
</tr>
</tbody>
</table>

1.10 SOME USEFUL REFERENCES


1.11 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1. • Hull, bran coat, endosperm and embryo position  
   • Contents of endosperm and embryo
2. • Water regime  
   • Ecosystem classification
3. • Area and seed rate for the nursery  
   • Water management and time of nursery
4. • Forms of urea used  
   • Application schedule
5. • Symptoms on leaf and leaf sheath  
   • Seed treatment and insecticide spray with dose
6. • Time of operation and water level  
   • Purpose related to crop stand and soil

Check Your Progress 2

1. • Area, production in last three decades  
   • Yield trend in last three decades
2. • Calorie supply  
   • Protein and carbohydrate content
3. • Bran utilization  
   • Hull utilization