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ECONOMIC BOTANY
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Rice (*Oryza sativa*)

ORIGIN

- Rice is regarded as a first cultivated crop of **Asia.**
- Preserved rice grains were found in China around **3000 B.C**.
- Paddy grains found during excavation at Hastinapur (India) around 1000-750 B.C. considered as an oldest sample in the world.
- Southwest Himalayas has various types and varieties and indicated probable centre of origin.
- **De Condolle (1886) and Watt (1862)** mentioned **south India** is its centre of origin.
- **Vavillov** suggested **that India and Myanmar** should be regarded as the centre of origin of cultivated rice.
- According to **D. Chatterjee (1948),** there are altogether **23 species of genus** *Oryza* of which 21 are wild and two viz., *Oryza sativa* and *Oryza glaberrima* are cultivated.
- *Oryza sativa* is grown in all rice growing areas, but *Oryza glaberrima* is confined to the **West Africa** only.

Thus it indicates that there might have been **two centres of origin** of our cultivated rice; South-eastern Asia (India, Myanmar and Thailand) and West Africa.

genetic study in 2011 that showed that all forms of Asian rice, both *indica* and *japonica*, sprang from a single domestication event that occurred 13,500 to 8,200 years ago in China from the wild rice *Oryza rufipogon*.

Rice was gradually introduced north into early Sino-Tibetan Yangshao and Dawenkou culture millet farmers, either via contact with the Daxi culture or the Majiabang-Hemudu culture. By around 4000 to 3800 BC, they were a regular secondary crop among southernmost Sino-Tibetan cultures. It did not replace millet, largely because of different environment conditions in northern China, but it was cultivated alongside millet in the southern boundaries of the millet-farming regions. Conversely, millet was also introduced into rice-farming regions.

The spread of *japonica* rice cultivation to Southeast Asia started with the migrations of the Austronesian Dapenkeng culture into Taiwan between 3500 and 2000 BC (5,500 BP to 4,000 BP). The Nanguanli site in Taiwan, dated to ca. 2800 BC, has yielded numerous carbonized remains of both rice and millet in waterlogged conditions, indicating intensive wetland rice cultivation and dryland millet cultivation.

Rice was cultivated in the Indian subcontinent from as early as 5,000 BC. "Several wild cereals, including rice, grew in the Vindhyan Hills, and rice cultivation, at sites such as Chopani-Mando and Mahagara, may have been underway as early as 7,000 BP.

Rice appeared in the Belan and Ganges valley regions of northern India as early as 4530 BC and 5440 BC, respectively.

The early domestication process of rice in ancient India was based around the wild species *Oryza nivara*. This led to the local development of a mix of 'wetland' and 'dryland' agriculture of local *Oryza sativa* var. *indica* rice agriculture, before the truly 'wetland' rice *Oryza sativa* var. *japonica*, arrived around 2000 BC.

MORPHOLOGY

Rice (oryza sativa) belongs to the family of cereal grasses, along with wheat, corn, millet, oats, barley, rye, and numerous others. The grass family provides the world with over 60% of its caloric intake and over 75% of the protein for developing nations.

he parts of the rice plant may be divided as follows:
- roots
- stem and leaves
- reproductive organs
- grain

II. Roots

As the underground portion of the plant, the roots serve as support, draw food and water from the soil, and store food. They are fibrous and consist of rootless and root hairs. The embryonic roots, or those which grow out of the seed when it germinates, nave few branches. They live for only a short time after germination. Secondary adventitious roots (i.e. roots appearing in an irregular pattern) emerge from the underground nodes of the young culm and replace the embryonic roots.

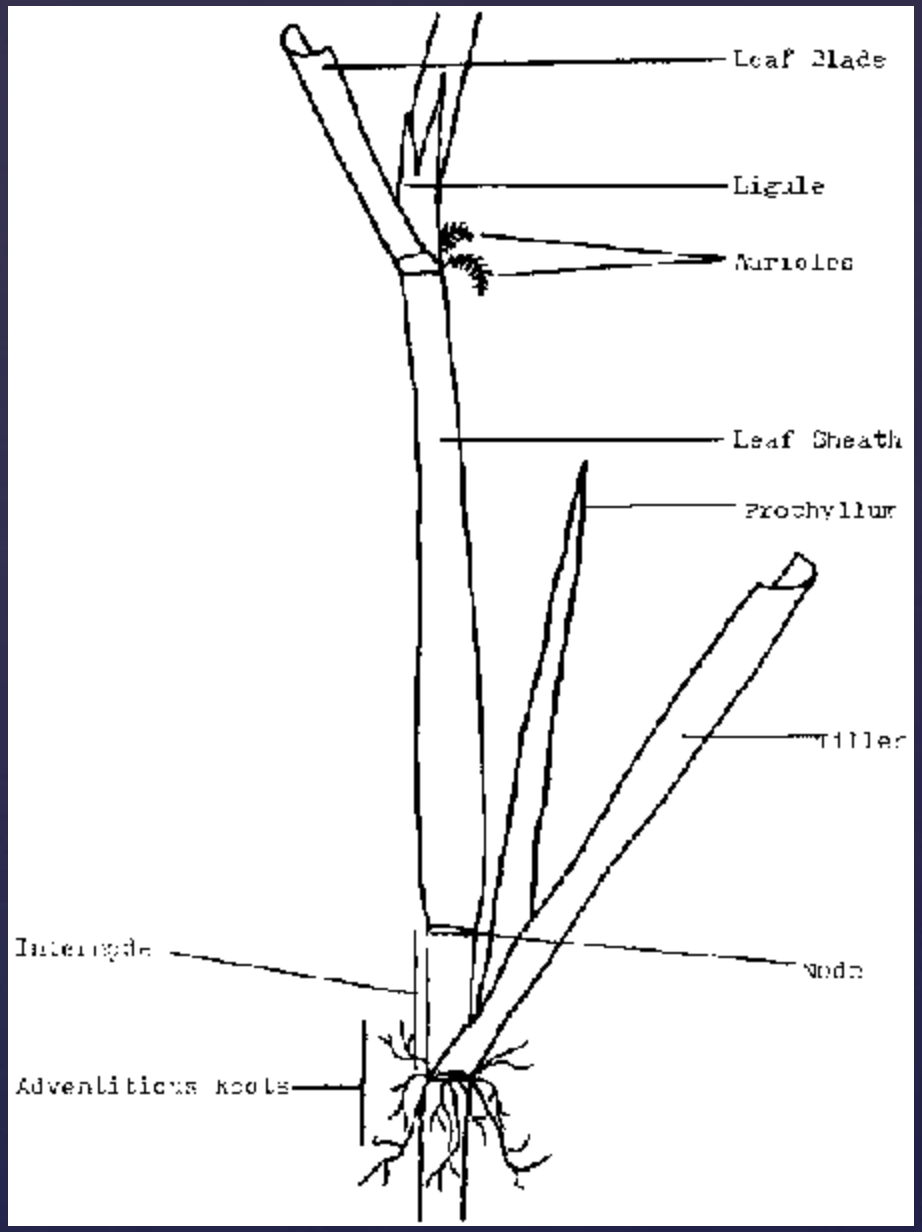
III. Stem and Leaves

a) Stem

The role of the stem (or culm) is to support the leaves and reproductive structures, and to transfer essential nutrients between the roots, the leaves, and the reproductive structures. The stem is made up of a series of nodes and internodes in alternating order.

b) Leaves

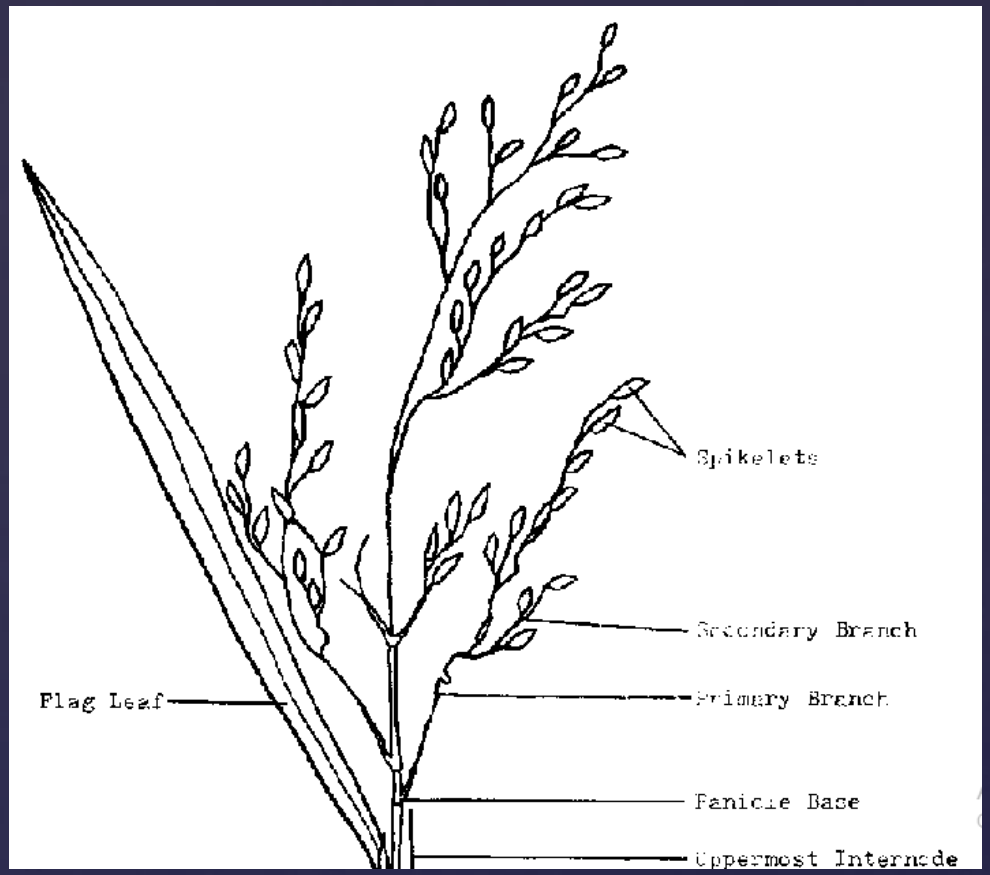
The leaves function as the principal organs of photosynthesis and respiration (i.e. they contain chlorophyll-containing cells which convert sunlight to chemical energy and synthesize organic "fuel" compounds from inorganic compounds). The leaves are borne at an angle on the stem in two ranks - one at each node. The uppermost leaf below the panicle, the flag leaf, provides the most important source of photosynthetic energy during reproduction.



III. Reproductive Organs

a) Panicle

The panicle, or flower cluster, contains the reproductive organs of the rice plant. Borne atop the uppermost node on the stem, the panicle is divided into primary, secondary, and sometimes tertiary branches bearing the spikelets. The branches may be arranged singly or in pairs. The panicle stands erect at blooming, but it usually drops as the spikelets fill, mature, and develop into grains. Varieties differ greatly in the length, shape, and angle of the primary branches, as well as in the weight of the overall panicle



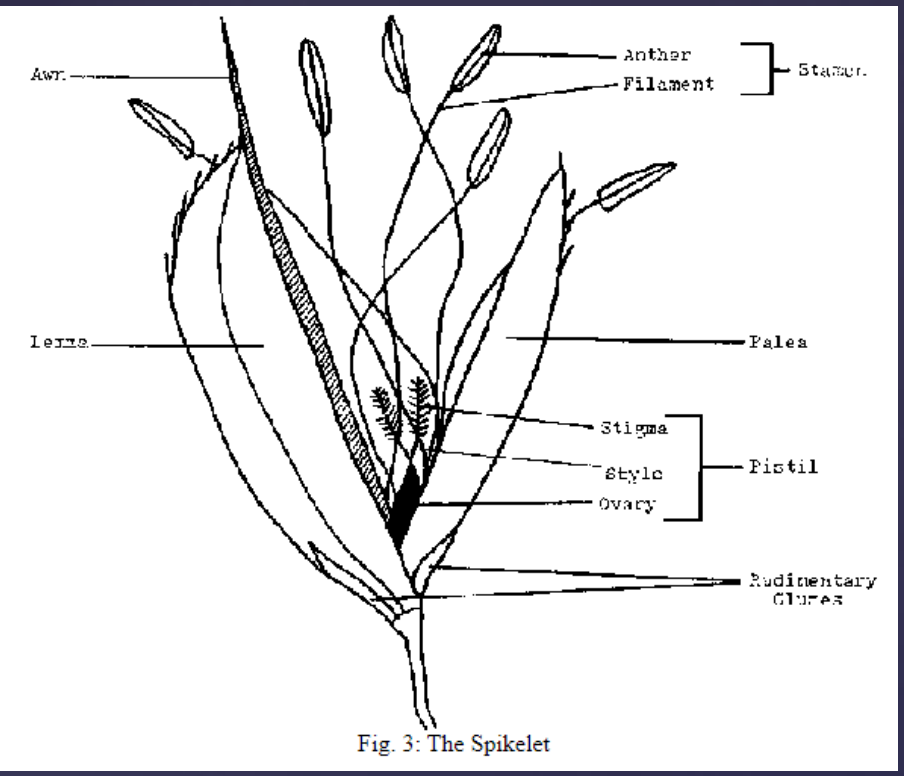


Fig. 3: The Spikelet

b) Spikelet

Each individual spikelet contains a set of floral parts flanked by the lemma and palea. The flower consists of six stamens and a pistil. The stamens (which contain pollen, or "sperm") are composed of two-celled anthers borne on slender filaments. The pistil consists of the ovary (containing the ovule, or "egg"), the style, and the stigma. During reproduction, the stigma catches pollen from the stamens and conducts it down to the ovary, where it comes into contact with the ovule and fertilization occurs.

V. Grain

The grain is the seed of the rice plant, a fertilized and ripened ovule containing a live embryo capable of germinating to produce a new plant. It is composed of the ripened ovary, the lemma and palea, the rachilla, the sterile lemmas, and the awn (not always present). The lemma and palea and their associated structures constitute the hull or husk. The embryo lies at the ventral side of the spikelet next to the lemma and contains the embryonic root. The rest of the grain consists largely of endosperm (the edible portion), containing starch, proteins, sugar, fats, crude fiber, and inorganic matter.

Cultivation and Processing

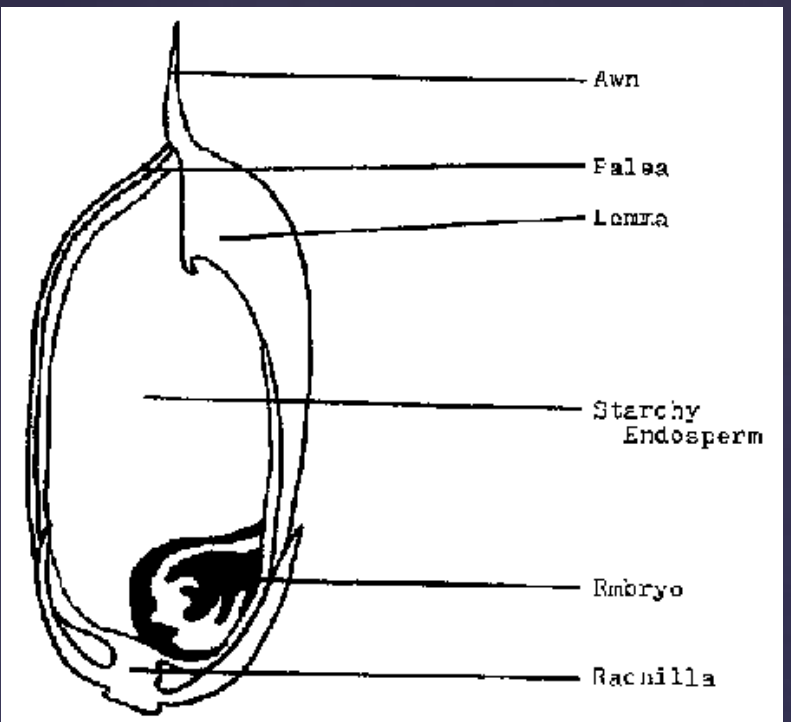


Fig. 4: The Grain

1. Seed quality and selection

Seed is a living product that must be grown, harvested, and processed correctly in order to realize the yield potential of any rice variety. Good quality seed can increase yields by 5-20%. Using good seed leads to lower seeding rates, higher crop emergence, reduced replanting, more uniform plant stands, and more vigorous early crop growth.

2. Land preparation

Before rice can be planted, the soil should be in the best physical condition for crop growth and the soil surface is level. Land preparation involves plowing and harrowing to 'till' or dig-up, mix and level the soil.

3. Crop establishment

The two main practices of establishing rice plants are transplanting and direct seeding.

Transplanting is the most popular plant establishment technique across Asia. Pre-germinated seedlings are transferred from a seedbed to the wet field. It requires less seed and is an effective method to control weeds, but requires more labor. Seedlings may be transplanted by either machine or hand.

Direct seeding involves broadcasting dry seed or pre-germinated seeds and seedlings by hand or planting them by machine. In rainfed and deepwater ecosystems, dry seed is manually broadcast onto the soil surface and then incorporated either by ploughing or by harrowing while the soil is still dry. In irrigated areas, seed is normally pre- germinated prior to broadcasting.

4. Water use and management

Cultivated rice is extremely sensitive to water shortages. To ensure sufficient water, most rice farmers aim to maintain flooded conditions in their field. This is especially true for lowland rice. Good water management in lowland rice focuses on practices that conserve water while ensuring sufficient water for the crop.

5. Harvest

Harvesting is the process of collecting the mature rice crop from the field. Depending on the variety, a rice crop usually reaches maturity at around 105–150 days after crop establishment. Harvesting activities include cutting, stacking, handling, threshing, cleaning, and hauling. Good harvesting methods help maximize grain yield and minimize grain damage and deterioration.

Harvesting can be done manually or mechanically:

Manual harvesting is common across Asia It involves cutting the rice crop with simple hand tools like sickles and knives. Manual harvesting is very effective when a crop has lodged or fallen over, however it is labor intensive. Manual harvesting requires 40 to 80 hours per hectare and it takes additional labor to manually collect and haul the harvested crop.

Mechanical harvesting using reapers or combine harvesters is the other option, but not so common due to the availability and cost of machinery. Following cutting the rice must be threshed to separate the grain from the stalk and cleaned. These processes can also be done by hand or machine.

Drying

7 Before milling, rice grains must be dried in order to decrease the moisture content to between 18-22%. This is done with artificially heated air or, more often, with the help of naturally occurring sunshine. Rice grains are left on racks in fields to dry out naturally. Once dried, the rice grain, now called rough rice, is ready for processing.

Hulling

8 Hulling can be done by hand by rolling or grinding the rough rice between stones. However, more often it is processed at a mill with the help of automated processes. The rough rice is first cleaned by passing through a number of sieves that sift out the debris. Blown air removes top matter.

From the shelling machine, the grains and hulls are conveyed to a stone reel that aspirates the waste hulls and moves the kernels to a machine that separates the hulled from the unhulled grains. By shaking the kernels, the paddy machine forces the heavier unhulled grains to one side of the machine, while the lighter weight rice falls to the other end. The unhulled grains are then siphoned to another batch of shelling machines to complete the hulling process. Hulled rice grains are known as brown rice.

Milling

Since it retains the outer bran layers of the rice grain, brown rice needs no other processing. However along with added vitamins and minerals, the bran layers also contain oil that makes brown rice spoil faster than milled white rice. That is one of the reasons why brown rice is milled further to create a more visually appealing white rice.

The brown rice runs through two huller machines that remove the outer bran layers from the grain. With the grains pressed against the inner wall of the huller and a spinning core, the bran layers are rubbed off. The core and inner wall move closer for the second hulling, ensuring removal of all bran layers.

The now light-colored grain is cooled and polished by a brush machine.

The smooth white rice is conveyed to a brewer's reel, where over a wire mesh screen broken kernels are sifted out. Oftentimes, the polished white rice is then coated with glucose to increase luster.

Wheat (*Triticum aestivum*)

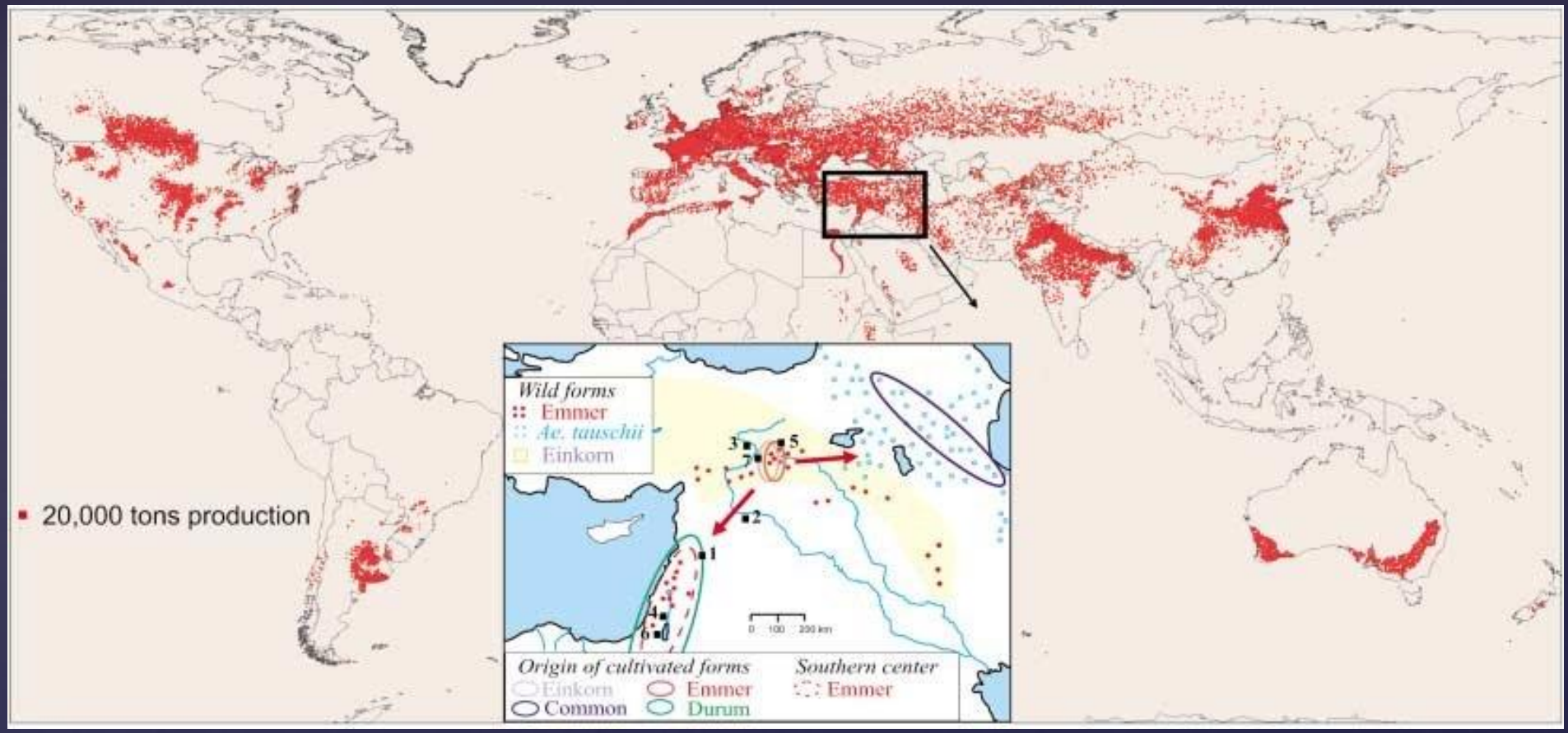
Wheat is a grass widely cultivated for its seed, a cereal grainwhich is a worldwide staple food. The many species of wheat together make up the genus ***Triticum***; the most widely grown is common wheat (*T. aestivum*).

ORIGIN

Archaeological analysis of wild *emmer* indicates that it was first cultivated in the southern Wheat (Triticum sp.) is a cereal grain originally from the Levant region of the near East and Ethiopian Highlands. It is now cultivated worldwide.

9600 BCE. Genetic analysis of wild *einkorn* ***Triticum monoccum*** wheat suggests that it was first grown in the Karacadag Mountains in southeastern Turkey. Dated archeological remains of einkorn wheat in settlement sites near this region, including those at Abu Hureyrain Syria, suggest the domestication of einkorn near the Karacadag Mountain Range.

By 3000 BCE, wheat had reached the British Isles and Scandinavia. A millennium later it reached China.



The cultivation of emmer reached Greece, Cyprus and Indian subcontinent by 6500 BC, Egypt shortly after 6000 BCE, and Germany and Spain by 5000 BC.

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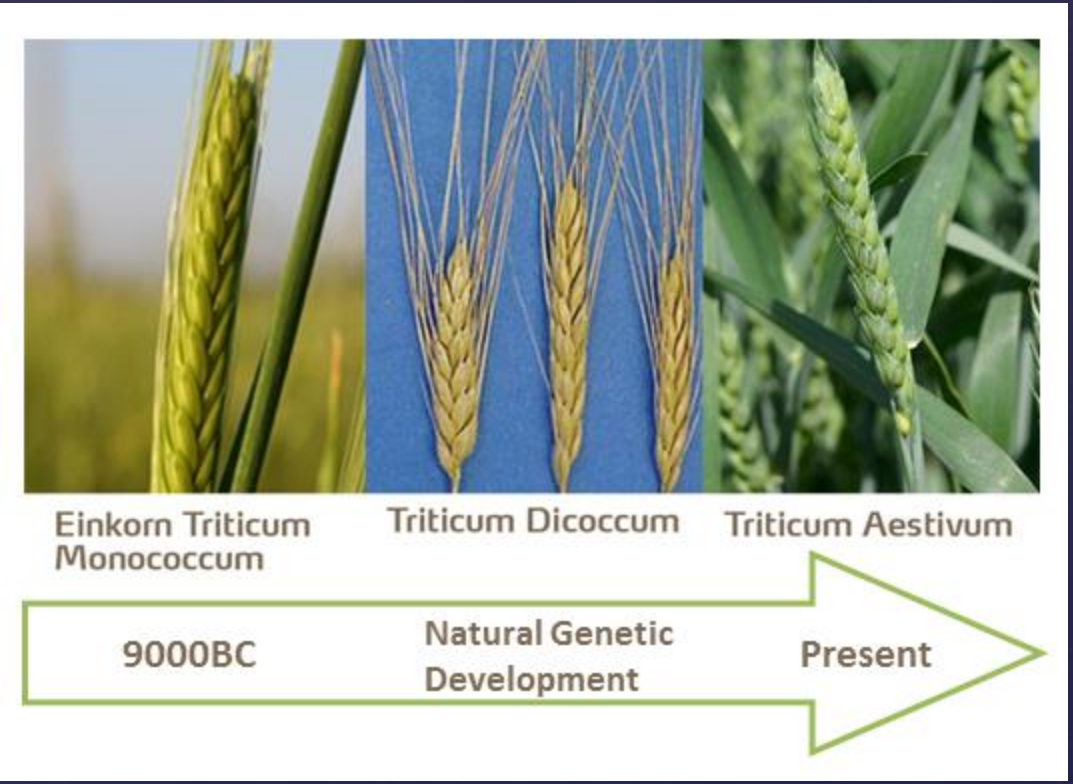
From Asia, wheat continued to spread across Europe. In the British Isles, wheat straw (thatch) was used for roofing in the Bronze Age, and was in common use until the late 19th century.

The distribution of the wild wheats and grasses, believed to be the progenitors of the cultivated wheats, supports the belief that wheat originated in southeastern Asia. Some species were cultivated in Greece, Persia, Turkey, and Egypt in prehistoric times while the cultivation of other species may be of more recent origin. In India, evidences from Mohen-Jo-Daro excavations, indicate that wheat was cultivated there more than 5000 years ago.



MORPHOLOGY

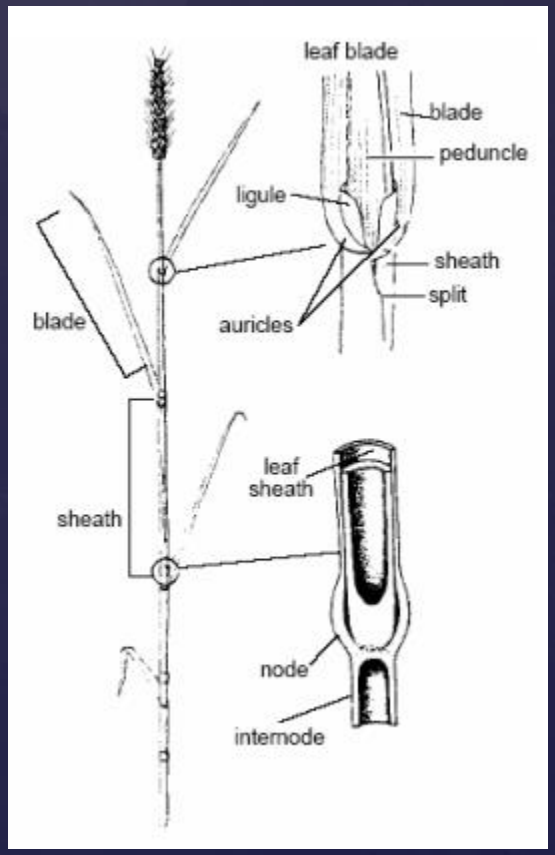
The plant is made up of a root and shoot system. Two types of roots are found, the seminal roots and the nodal roots (adventitious or crown roots), which arise from the lower nodes of the shoot. The shoot is made up of a series of repeating units or phytomers, each potentially having a node, a leaf, an elongated internode and a bud in the axil of the leaf

ROOTS

The wheat plant has two types of roots, the seminal (seed) roots and roots that initiate after germination, the nodal (crown or adventitious) roots.

LEAVES

The leaf is divided at the ligule into a cylindrical sheath and the flat blade or lamina. The sheath is tubular at the base, but nearer to the blade it is split and the margins overlap. The lamina has a fairly well-marked midrib, along which runs the major vascular bundle of the leaf.

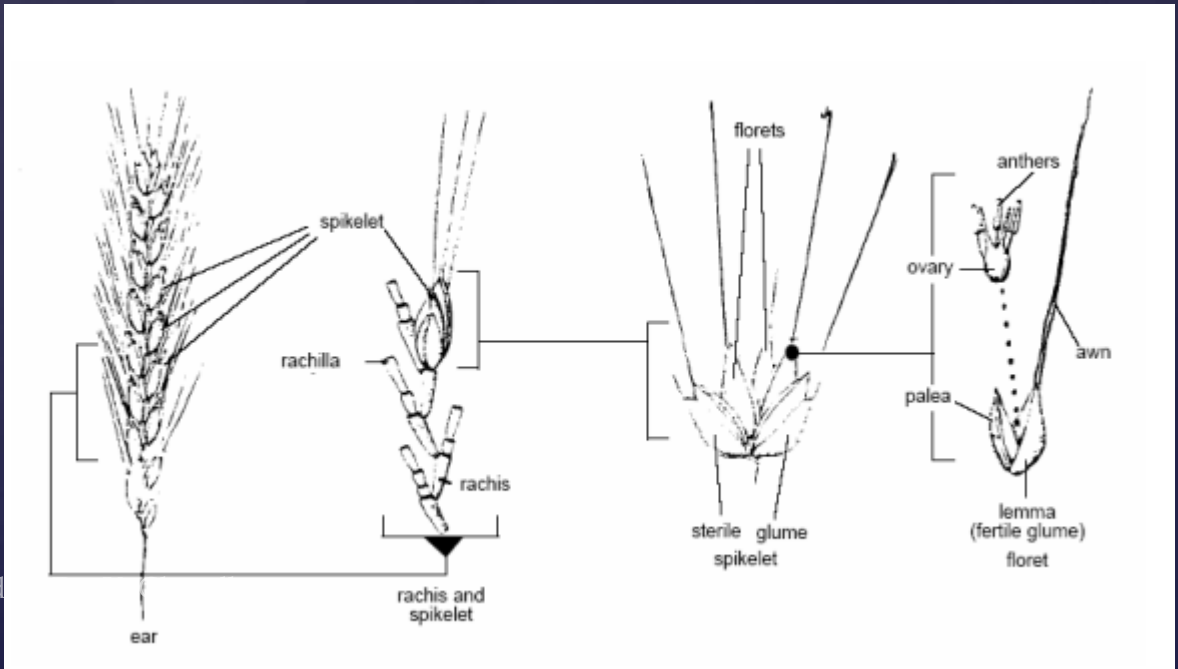


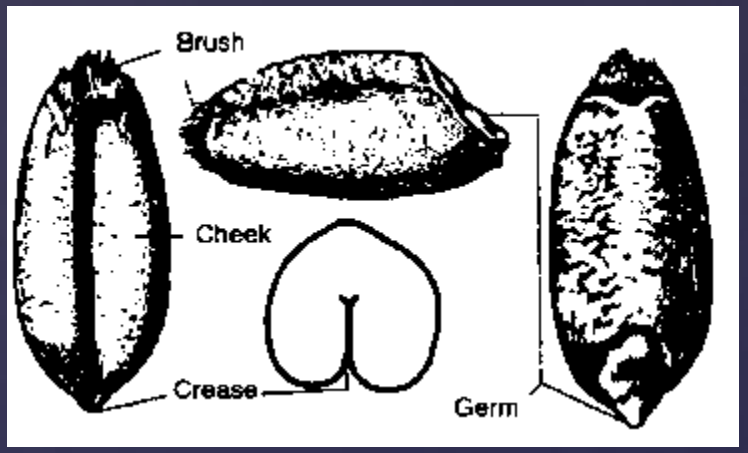
TILLERING

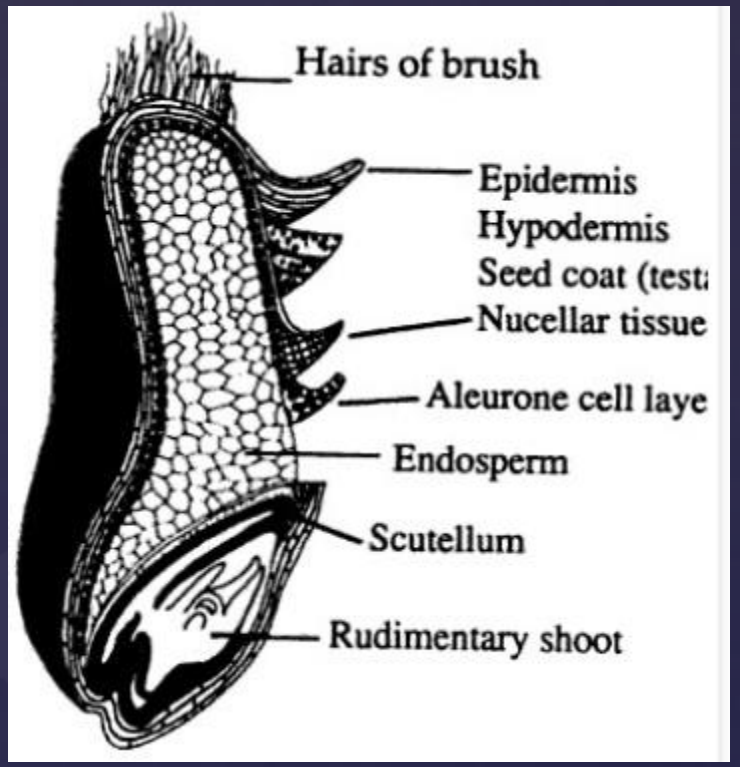
The wheat plant has the ability to tiller, i.e. to produce lateral branches. At the end of the vegetative phase of development, the plant will consist of, in addition to the main shoot, a number of tillers.

THE EAR

As it approaches anthesis, the ear is completely formed and the pollen grains and carpel are fully developed. After anthesis, the florets open, pollen is released and the carpels are pollinated. The stamens and lodicules, their role fulfilled, die and shrivel, and further growth and development takes place in the carpels, the developing grains.




Brush
Cheek
Crease
Germ


Hairs of brush
Epidermis
Hypodermis
Seed coat (test
Nucellar tissue
Aleurone cell laye
Endosperm
Scutellum
Rudimentary shoot

Uses of Wheat

- **Wheat is milled to produce flour which is used to make a variety of products**

Wheat contains a protein called gluten which is necessary for the basic structure in forming the dough system for bread, rolls and other baked goods. bread, cookies, cakes, pies, pastries, cereals, crackers, pasta, flour tortillas and noodles are all made from wheat flour.

CULTIVATION AND PROCESSING

Land Preparation:

The wheat crop requires a well-pulverized but compact seed bed for good and uniform germination. Three or four ploughings in the summer, repeated harrowing in the rainy season, followed by three or four cultivations and planking immediately before sowing produce a good, firm seed bed for the dry crop on alluvial soils.

Sowing:

a)Sowing time:

Based on above temperature requirement it has been found that for indigenous wheat last week of October, for long duration dwarf varieties like Kalyansona, Arjun, etc. first fortnight of November and for short duration dwarf wheats like Sonalika, Raj 821 etc. second fortnight is the best sowing time. Under exceptionally late sown condition it may be delayed to latest by 1st week of December beyond which if area is very small transplanting may be practiced.

b) Seed rate:

Generally, a seed rate of 100 kg/ha has been found to be sufficient for most of the varieties like Kalyan Sona, Arjun, Janak, etc.which have moderate tillering and medium sized grains. But a higher seed rate of 125 kg/ha is desirable for late sown wheat and normal sown for varieties like Sonalika, Raj 821 etc. which have bold grains and shy tillering habits.

c) Spacing: :

For irrigated, timely sown wheat, a row spacing of 15 to 22.5 cm is followed, but 22.5 cm between the rows is considered to be the optimum spacing. Under irrigated late-sown conditions, a row spacing of 15-18 cm is the optimum. For dwarf wheats, the planting depth should be between 5 and 6 cm. Planting beyond this depth results in a poor stand. In the case of conventional tall varieties, the depth of sowing may be 8 or 9 cm.

d) Seed treatment:

The seed of loose smut-susceptible varieties should be given solar or hot-water treatment. If the wheat seed is used only for sowing, and not for human consumption or for feeding cattle, it can be treated with Vitavax.

Application of Mannures and Fertilizer

It is desirable that 2 to 3 tonnes of farmyard manure per hectare or some other organic matter is applied 5 or 6 weeks before sowing. The fertilizer requirement of the irrigated wheat crop are as follows:

With assured fertilizer supply:
Nitrogen (N) @8- - 120 kg/ha
Phosphorus (P_2O_5) @ 40- 60 kg/ha
Potash (K_2O) @ 40 kg/ha.
Under fertilizer constraints:
N @ 60-80 kg/ha
P_2O_5 @ 30-40 kg/ha
K_2O @ 20-25 kg/ha.

Irrigation:

The high yielding wheat varieties should be given five to six irrigations at their critical growth stages viz. Crown root initiation, tillering, jointing, flowering, milk and dough which come at 21-25 days after sowing (DAS), 45-60 DAS, 60-70 DAS, 90-95 DAS, 100-105 DAS and 120-125 DAS respectively. Off these irrigation at CRI stage is most important.

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Harvesting and Storage:

a) Harvesting:

The rain-fed crop reaches the harvest stage much earlier than the irrigated crop. The crop is harvested when the grains become hard and the straw becomes dry and brittle.The harvesting is mostly done by sickle. The crop is threshed by treading with cattle on the threshing-flour or by power driven thresher.

b) Yield: The national average yield of wheat grain is about 12 to 13.8 quintals per hectare.

c) Storage:

The grains should be thoroughly dried before storage. The storage life of the grain is closely related to its moisture content. Grains with less than 10 percent moisture store well. The storage pits, bins or godowns should be moisture-proof and should be fumigated to keep down the stored – grain pests including rats. Zinc phosphide is very effective against rats.