

PART II  
**CROP PRODUCTION IN INDIA**

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# CROP PRODUCTION IN INDIA

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CHAPTER I

DISTRIBUTION AND ECONOMIC IMPORTANCE OF FIELD CROPS

Indian agriculture consists mainly of the production of crops. These are of three kinds: first in importance are the field crops, second, are the vegetable crops; and the third, the fruit crops. Of these three, the first is by far the most important in this country, as the area occupied by field crops is very much greater and the total production is also many times greater than that of the other two kinds.

Of the field crops grown in this country, rice occupies by far the largest area. The other important field crops grown in this country are given in the following table which gives the acreage during the three-year period from 1938-'39 to 1940-'41.

TABLE I  
Statistics of area in thousand acres under principal crops in India.

<i>Name of crop</i>	1938-39	1939-40	1940-41
Rice .. .. .	79,233	80,204	77,434
Wheat .. .. .	36,082	34,734	35,602
Sugarcane .. .. .	3,287	3,806	4,762
Cotton .. .. .	23,513	21,602	23,303
<i>Jowar</i> .. .. .	35,000	35,900	35,400
Barley .. .. .	7,000	6,900	7,100
<i>Bajra</i> .. .. .	19,100	19,700	20,400
Tobacco .. .. .	1,321	1,346	1,291
Gram .. .. .	17,300	17,300	18,300
Linseed .. .. .	4,083	3,939	3,845
Groundnut .. .. .	8,100	8,600	7,100
Maize .. .. .	8,000	8,100	8,000
Jute .. .. .	3,200	3,200	4,400
Sesamum .. .. .	5,210	4,850	4,914
Mustard and rape .. .. .	5,862	6,443	6,510
Castor .. .. .	1,599	15,940	15,760
Coconut .. .. .	1,474	1,496	1,482



The figures in the above table show that of the important field crops, rice stands easily first in the order of acreage sown under each crop, followed by wheat, *jowar*, cotton, *bajra*, gram, groundnut, etc. The figures further indicate that the production of field crops occupies a very important place in the agricultural industry in this country. The production of fruits and vegetables, as well as the raising of cattle is still of secondary importance.

The relative importance of field crops, fruits, vegetables, etc., is to a great extent indicated by the following table.

TABLE 2

Areas in thousand acres under the different classes of crops in India.

<i>Classes of Crops</i>	<i>Acreages in 1941-42</i>
Foodgrains (rice, wheat, barley, jowar, bajra, maize and gram) .. .. .	156,500
Fibres .. .. .	21,310
Oilseeds .. .. .	25,458
Fodder crops .. .. .	10,500
Sugar .. .. .	3,600
Condiment and Spices .. .. .	1,500
Drugs and Narcotics (Tea, Coffee, tobacco, opium, etc.)	2,197
Dyes (Indigo only) .. .. .	660
Fruits and vegetables .. .. .	4,700

TABLE 3

Showing the estimated value of field crops in rupees.

<i>Name of Crop</i>	<i>Total production in maunds</i>	<i>Average price per maund in rupees</i>	<i>Estimated total value in rupees</i>
Rice .. .. .	842,587,200	5.314	40,477,508,380
Wheat .. .. .	257,275,200	3.566	917,443,363
Raw Sugar (gur) .. .. .	133,660,800	4.564	610,027,891
Cotton .. .. .	24,917,069	23.904	595,617,617
Jowar .. .. .	169,014,300	2.614	441,803,380
Barley .. .. .	65,820,300	2.619	172,383,365
Bajra .. .. .	58,094,400	2.682	155,809,180
Tobacco .. .. .	15,315,300	12.542	192,084,492
Gram .. .. .	103,166,700	2.700	278,550,090
Linseed .. .. .	10,264,800	5.290	54,300,792
Groundnut .. .. .	90,909,000	3.000	272,727,000
Maize .. .. .	51,979,200	2.517	130,831,466
Jute .. .. .	9,287,803	8.172	75,899,926
Sesamum .. .. .	14,679,300	7.675	113,354,377
Mustard and rape .. .. .	25,743,900	6.324	24,688,263
Castor .. .. .	3,903,900	..	..

*Rice.*—The figures in the above table indicate that rice is by far the leading crop of India. It occupies about 24 per cent, of the total area sown. Its cultivation is mainly confined to the more humid regions of the country and it is therefore grown mostly in Bengal, Bihar, Orissa, Madras and parts of the United Provinces, the Central Provinces, Assam and Bombay. It is the staple food of the people in the eastern part of the country.

India is also by far the greatest rice-producing country in the world. Its total output in 1940-41 was 22,191,000 tons. Other important rice-producing countries of the world are Japan, Indo-China, Indonesia, Siam, Korea, Formosa, the United States of America, Italy and Egypt.

India is also the greatest exporter of rice in the world, although her average export rarely exceeds 6 to 8 per cent of her total production.

*Wheat*—This is another very important crop in this country and occupies an acreage of about 10 per cent of the total area sown. Its cultivation is mainly confined to the Punjab, the United Provinces, the Central Provinces and Berar, the Central India States, Bombay and Bihar. But the Punjab and the United Provinces account for about 48 per cent of the total area sown and 56 per cent of the total yield.

Wheat is the staple food of many of the people living in Northern India. India is one of the important wheat-producing countries as it produces about ten per cent of the world's wheat and also occupies the fourth place amongst the wheat-producing countries of the world. Its present production of wheat, however, is approximately equal to her requirements and consequently the export of wheat during the last few years was on a limited scale.

The wheat-producing countries of the world named in the order of importance are the U. S. A., the U. S. S. R., Canada, India, France, Italy, Argentine, Australia, Spain and Germany.

*Sugarcane*—The area under sugarcane in India is larger than in any other country in the world; and, during the last few years, the acreage under this crop has been increasing very rapidly. Its cultivation at present is mainly confined to the United Provinces, Punjab, Bihar, and Orissa, but it is grown to some extent in Madras, Bombay and Assam. The United Provinces alone has more than 50 per cent of the total area devoted to sugarcane in this country, while it, with the Punjab, occupies about two-thirds of the total area sown to this crop.

In spite of the large acreage devoted to this crop, India produces enough sugar to meet only her own demands. This is largely due to the low yields per acre, which makes it just able to meet the demands of the population of this country. India's annual consumption of sugar is approximately one million tons. The countries of the world which produce sugar from sugarcane, arranged in their order of importance, based on the production of raw sugar are the

following: Indonesia, Hawaii, Porto Rico, India, Formosa, Argentine, Australia, Peru, Union of South Africa and Mexico.

*Cotton*—India is one of the most important cotton-growing countries of the world. Its acreage, as well as its total production, is second only to that of the United States of America. The area devoted to this crop in India has varied from about 22 to 25 million acres, and its total production has also varied from a little over 4½ to about 7 million bales annually. Its cultivation is mainly confined to the “black cotton” soil area of India but is also grown in the alluvial soils of the Indo-Gangetic plains. India is also one of the important cotton-exporting countries of the world being second only to the U. S. A.

The major cotton-growing countries of the world, named in their order of importance are the U. S. A., India, the U. S. S. R., Egypt, Brazil, Uganda, Argentine, Anglo-Egyptian Sudan and Australia.

The above discussion clearly shows the very important place India occupies amongst the major countries as a producer of the important crops of the world. It also shows that field crop production holds a very important place in the agriculture of India.

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## CHAPTER II

### WHEAT

*Origin and history:*—The growing of wheat began very early in pre-historic times. Its culture is so old that the origin of wheat is still a matter of speculation. Wheat has also been known for a very long time to people of various parts of the world. Records in ancient China show that it was cultivated there by 2700 B. C. It was also known to the ancient Egyptians and to inhabitants of Switzerland as early as the Stone Age. De Candolle believed that wheat originated in the valley of the Tigris and Euphrates, and spread from there to China, Egypt and other parts of the world. Some of the American writers believed that wheat probably originated in Syria and Palestine, mainly on the evidence of Aaronsohn who brought a type of wild wheat from that country. More recently, Vavilov, after more extensive studies of the origin of cultivated plants, came to the conclusion that the origin of the durum wheats was probably in the region of Abyssinia, whereas the whole group of soft wheats, which include the bread wheats, probably originated in the region adjoining Northern India, south-western Afghanistan, and the southern parts of mountainous Bokhara. This conclusion is based on the fact that there are a great number of forms of wheats showing dominant characters in these two regions.

*Distribution in India*—Wheat is one of the most important crops in India. The total area under this crop is about 36 million acres. The total estimated yield in a year is about 12 million tons. Its distribution according to provinces is as shown in Table 4.

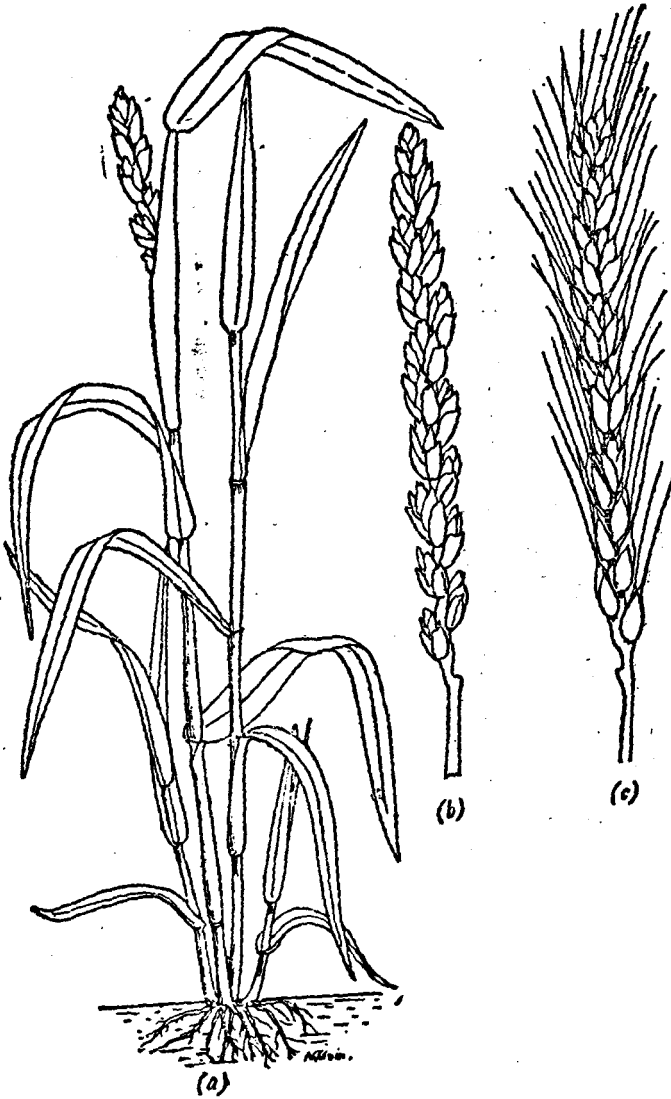


Figure 1. The wheat plant  
(a) The wheat plant; (b) an ear of I. P. 4 wheat; and (c) an ear of a local (Allahabad) wheat. (Drawn by N. N. Uzir)

TABLE 4

Showing the distribution of wheat according to provinces.

Province	Area in thousand acres		Yield in thousand tons	
	1937-38	1940-41	1937-38	1940-41
Punjab .. ..	9,945	9,884	3,724	3,339
United Provinces .. ..	7,800	7,935	2,277	2,845
C. P. and Berar .. ..	3,358	3,229	673	572
Bihar .. ..	1,098	1,096	307	405
Sind .. ..	1,155	1,203	351	331
Bombay .. ..	1,827	1,752	380	301
N.-W. F. Province .. ..	1,028	1,088	268	259
Bengal .. ..	161	169	45	34
Delhi .. ..	46	48	20	16
Ajmer-Merwara .. ..	21	24	7	7
Total for Indian States	9,165	9,165 <sup>1</sup>	2,153	2,150 <sup>1</sup>

Thus this crop is grown practically all over India except in the regions at the mouth of the Ganges in Bengal and many of the districts of Assam. However, the greatest part of this crop is grown in the northern provinces of India and also on the Malwa plateau. On the average, the Punjab and the United Provinces together have about 50 per cent of the total area under wheat in India, and produces about 61 per cent of the total crop.

*Botanical description*—Wheat is a member of the grass family, one of the most important of the families of plants to man, as almost all of the cereals, sugarcane, and many of the important forage crops belong to this family. Thus rice, barley, *jowar*, *bajra* and sugarcane are all related to wheat. Wheat is an annual plant, that is, it grows and dies in the course of one year. In this country, wheat is grown in the winter season, except in the mountainous regions where it is grown in the summer.

The wheat plant usually grows to a height of about 2½ to 5 feet, depending on the fertility of the soil and on

<sup>1</sup> approximately.

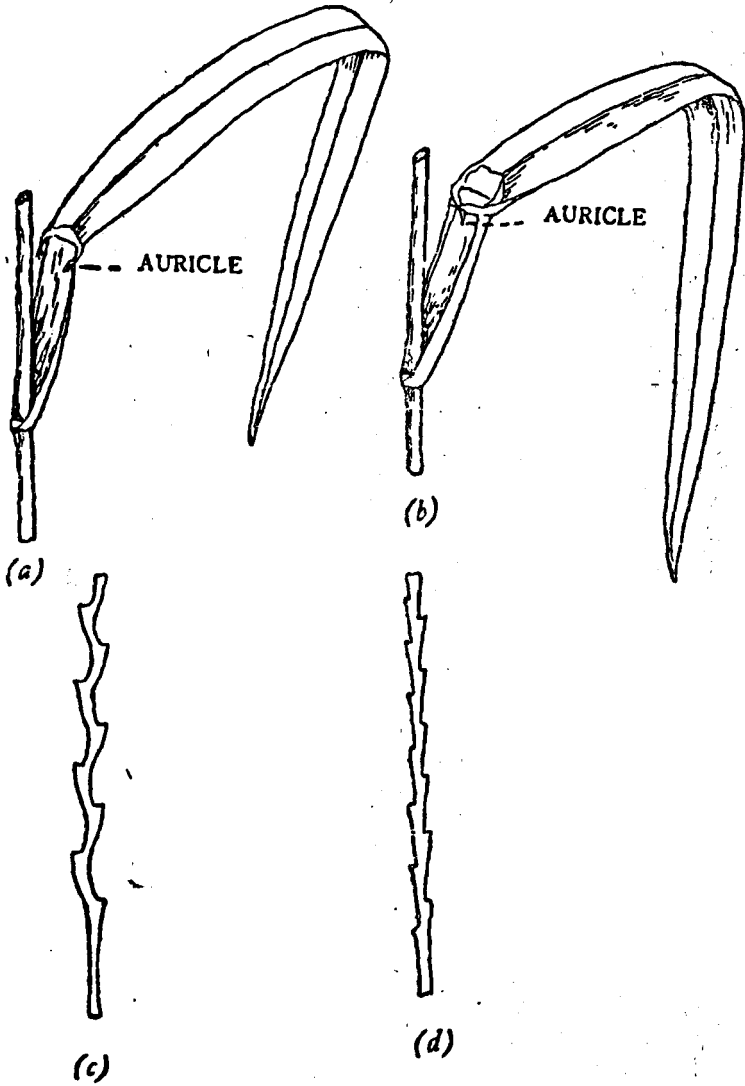


Figure 2. Leaf and rachis of the wheat and barley plants.  
 (a) Part of the wheat stem showing the auricles; (b) part of the  
 barley stem also showing the auricles; (c) part of the wheat  
 rachis; and (d) part of the barley rachis.



the variety grown. In general, the macaroni wheats are also taller than the common bread wheats. But the particular height attained depends also on external factors. The stems or culms of the wheat plant are round or cylindrical. In most varieties of the bread wheats the stems are hollow except at the nodes where they are solid, but in a few varieties of macaroni wheats the internodes are completely filled with a soft pith. During the early growth of the stem, the nodes or joints are very close together but later the internodes elongate until the plant reaches its full height.

Wheat in common with other cereals throws out branches, which are known as "stools" or "tillers". The degree of tillering depends on the race or variety grown, as well as on other external influences, such as the fertility of the soil, spacing and seasonal conditions. These tillers develop from buds that are produced in the axil of the leaf, at the under-ground nodes. Some wheats have been known, under favourable circumstances, to produce fifty or more tillers in one plant.

The young shoots of wheat sometimes show distinct differences in habit of growth. Some types, at the early stages of growth, stand up more or less erect, and are therefore known as the "erect" types. The second group of wheat show a prostrate habit of growth, and hence are known as "creeping" wheats. This creeping habit is believed to be very closely related to winter hardiness. The wheats with this habit also do not easily lodge. The third group of wheats show a habit intermediate between the erect and the prostrate types, and may be called an "intermediate" type.

Another characteristic of wheat stems in common with other cereals is what is known as "lodging", which is the bending of the plants causing them to lie more or less flat on the ground. This phenomenon is usually associated with weak stems and also with nutrition, especially with the presence of an excess of nitrogen in the soil, or with an excess of irrigation water. But the character of

the root system also influences the degree of lodging in the wheat crop. Lodging may also be encouraged by the crowding of the plants, which causes weakness of the stems due probably to an etiolation effect caused by insufficient light. From the chemical viewpoint, investigations by Lawes and Gilbert have shown that lodging is associated with liquification of the tissues and a correspondingly low proportion of silica.

Stems of wheat do not elongate indefinitely but sooner or later produce ears or spikes which bear the grain. This phenomenon is known as the "shooting" of the ear or "booting". The time taken to reach the "earing" stage, in other words the "earliness" or "lateness" of the wheat crop, is a character inherent in the plant itself, and is therefore, more or less a constant hereditary character.

The wheat leaf consists of four parts: (1) the blade or lamina; (2) the sheath, the part which clasps the stem tightly; (3) the ligule or rain-guard, a thin membrane growing at the junction of the blade and the sheath; and (4) the auricles, which are curved claw-like appendages attached to the base of the blade and generally clasping the stem, from opposite sides (See figure 2, page 17).

The blade of the wheat leaf varies considerably in different varieties in length, width, smoothness and prominence of veins. The sheaths normally cover about the lower-two thirds of the culm, and overlap on the side opposite the blade. The leaf sheath may vary in colour from purple to light-straw. The ligule or rain-guard prevents the entrance of rain water, dust, aphides and other insects, between the sheath and the stem. This structure is sometimes made use of in distinguishing wheats from barley or oats. Oats do not possess any auricles, whereas those in barley are very prominent and much larger and more conspicuous than those of wheat. These structures are either light-green or pinkish in colour.

The inflorescence of wheat is arranged in a long, narrow, compact cluster at the top of the stem and is known as the "spike" or "head". It is made up of groups of

flowers known as spikelets, each spikelet being a flower or a group of flowers enclosed in a pair of glumes, which are concave scales or bracts inserted on a short stem known as the rachilla. In wheat, there is only one spikelet at a node on the rachis, whereas in barley there are three spikelets at each node. That portion of the stem extending through the spike, to which the flowers are attached is known as the rachis. The spikelets are borne on alternate sides of the rachis, which gives it a zigzag appearance. The character of the rachis may be used to distinguish wheat from barley, as in the latter the rachis is more flattened and less zigzag (See figure 2, page 17). At each node on the rachis in the wheat plant there is a cushion-like end for the attachment of the rachilla. This character also is sometimes used for distinguishing wheat from barley.

Spikes differ greatly in form and degree of compactness. In some wheats the spikelets are specially crowded on the ears near the tip, but arranged in a lax, open manner toward the base. Such ears are referred to as "clubbed", and hence the name of "club wheat" is given to this group of wheats.

Spikes may be either "awned" or "awnless" (see figure 1, page 11). An awn is a tapering projection from the flowering glumes (lemmas) at each spikelet. Awns are agriculturally important for they are characters which are readily apparent, and hence used in classifying wheat. Awns usually decrease in length from the basal part of the spike upward. The length of the awns, however, depends on the variety or race of wheat. The macaroni or *durum* wheats usually possess very long awns, whereas the bread wheats are either awned or awnless, and when awned the length of the awns is usually less than that of macaroni wheat. Absolutely awnless wheats are, however, of exceptional rarity. Hence in the classification the term awnless or beardless is used for those wheats in which the awns are altogether absent or not more than one centimeter in length and confined to the tip of the ear. Truly bearded wheats usually have a uniform distribution of awns from the top

to the bottom of the spike and the longest is never at the top. On the basis of this character, all varieties of wheat are classed as awned (bearded) or awnless (beardless). Awns also possess different colours, which vary from light-straw colour, to red and black. The black pigment, however, may appear or disappear according to certain climatic conditions, such as intensity of light, heat and moisture during the ripening period. This character therefore cannot be relied upon for use in the classification of wheats.

Spikes may also be flattened parallel to or at right angles to the plane of the face of spikelets. All common bread wheats are flattened parallel to this plane and are therefore dorsoventrally compressed. But the spikes of macaroni and club wheats are flattened at right angles to the plane of the face of the spikelets and are therefore laterally compressed.

A wheat flower consists of three stamens with thread-like filaments and rather large anthers. The single ovary has two feathery stigmas. There are two lodicules, structures which are instrumental in the opening of the flowers. This is performed by the swelling of the lodicules causing the separation of the lemma and the palea or palet. The spike takes several days to complete its flowering. Considering the entire plant, flowering takes place on the main stem followed by the tillers in the order of their development.

Wheats are generally considered to be self-fertilized plants, although a very small percentage of natural crossing may occur. Natural crossing, however, is believed to be more common in macaroni or durum wheats, and in hot dry countries more than in countries with a wet and cold climate. In this connection, Howard reports that more cross-pollination took place at Lyallpur in the Punjab than at Pusa in Bihar.

The roots of a wheat plant like those of other grasses are fibrous. On the germination of the grain, seminal or temporary roots are produced, and are then followed by permanent roots usually at some distance above the tem-

porary roots. The first permanent roots are usually formed at a depth of about one or two inches below the soil surface, regardless of the depth at which the seed is planted. These permanent roots at first spread out laterally and then descend almost vertically downwards sometimes reaching a depth of about four feet under favourable conditions. The number of roots generally increases with the number of tillers in the plant.

*Ecological factors*—Wheat is adapted to varying conditions of climate and soil. In India, however, wheat growing is mainly confined to the regions of cool winters. Its cultivation is therefore confined to the northern, and to some extent to the central portions of the country. In general it does not do well in the southern part of the country nor in the humid regions, such as Bengal. The best wheats are produced in the northern-most part of the country where the winters are cold.

Although most of the wheat areas in this country are in the low level plains of the Indus and the Ganges, some wheat, however, is also grown in the higher regions, such as on the Malwa plateau, the hilly regions of the North-West Frontier Province, and to some extent in the regions of the Himalayas.

Wheat is grown in India where the annual rainfall varies from 5 to 45 inches. But in most places where the rainfall is less than 30 inches, irrigation is required for profitable production. But even in such regions "dry farming" or "*barani*" cultivation is sometimes adopted. The yield from this method of cultivation is usually very low.

It must not be inferred, however, that one type of wheat is grown in all those regions where there are varying amounts of rainfall and different degrees of temperature. Usually durum or macaroni wheats require less rain than the common bread wheats.

Wheat is also grown in different types of soil in this country, but it does best on the heavier soils such as loams and clay loams. And, while it makes its best growth in

the alluvial soils of the Indo-Gangetic plain, it also does well on the black cotton soil of Central India and parts of the Central Provinces. But the bread wheats are typical of the alluvial soils, whereas the durumms are mainly confined to the black cotton soil.

Wheat in India is frequently subject to frost, but it is seldom severe enough to do much damage. However, in case of late frost, after the ears have headed out, the damage caused to the crop may be serious.

*Classification of the Indian Wheats*—According to A. E. Watkins, there are altogether fourteen different species of wheat in the genus *Triticum*, divided into three groups on the basis of the number of chromosomes. The first group, represented by *T. agilopoides* Bal., a wild form of wheat, contains 14 chromosomes. The second group which is represented in India by *T. durum* Desf., the macaroni wheat, and *T. dicoccum* Schubl., emmer wheat, contains 28 chromosomes. The third group, which is represented in India by *T. vulgare* Host., the common bread wheat, and *T. Sphaerococcum* Perc., the Indian dwarf wheat, contains 42 chromosomes. Of these fourteen species of wheat, four are commercially grown in this country. These are the common bread wheat (*Triticum vulgare*), durum or macaroni wheat (*T. durum*), the Indian dwarf wheat (*T. sphaerococcum*), and emmer wheat *T. dicoccum*.

*A Key to the Classification of Indian Wheats.*

A. Stems solid, or hollow with thick walls; rachis more or less fragile; empty glumes long and narrow; outer face flattish; keel very prominent from tip to base; grains long and narrow; number of chromosomes, 28.

B. Apical tooth on empty glumes short and blunt; coleoptile 4-6 nerved.  
*T. dicoccum* (emmer).

BB. Apical tooth on empty glumes stout, generally acute, and curved inwards; coleoptile 2-nerved.

*T. durum* (macaroni wheat.)

AA. Stems hollow with thin walls, (occasionally in *T. vulgare* solid upper internodes); rachis, tenacious; empty glumes, broad with outer face, convex; keel, less prominent or in the upper half only; grains, plump; number of chromosomes, 42.

B. Apical tooth on empty glumes, short, more or less acute, or sometimes prolonged into an awn; grains, rounded on dorsal side.

*T. vulgare* (common bread wheat.)

BB. Apical tooth on empty glumes, strong, curved and scabrid; grain angular.

*T. sphaerococcum* (Indian dwarf wheat.)

Emmer wheat (*T. dicoccum*, Schubl.)—Howard reports that there is a single variety of emmer in this country. It occurs in the south of the wheat-growing area—Bombay, Madras, Mysore and to a very small extent in Berar. It is believed to have developed from *T. dicoides* Korn, a wild form. Emmer is one of the most ancient cultivated cereals. It is grown commercially to some extent in Spain, Italy, Germany and Russia.

Macaroni wheat (*T. durum* Desf.)—This wheat is grown largely in the black cotton soils in Central India, parts of the Central Provinces, and to some extent in the western districts of the Punjab, Madras, Mysore and in the Malda district of Bengal. The Malwi wheats of Central India and the *dautia* wheats of Hoshangabad in the Central Provinces are durum wheats. The *wadanak* wheats of the Punjab are also forms of durum and are reported to be good for making *chapatis* (unleavened bread), and are used exclusively in the manufacture of sweetmeats which are eaten by all classes of people. In European countries, this wheat produces the flour from which macaroni is made, whence it got its name. It is commonly grown in Italy, Central and South America, Russia and the United States of America. Durum wheats are believed to have descended from emmer.

Common bread wheat (*T. vulgare*, Host)—The common bread wheat is typical of the alluvial soils of the Indo-Gangetic plains, especially in the Punjab, the United Pro-

vinces, Bihar, Sind and parts of Rajputana. The bulk of the Indian crop, therefore, consists of this type.

Indian dwarf wheat (*T. sphaerococcum* Perc.)—Wheats of this type were thought by Howard to belong to *T. compactum* or the Club wheats of western countries. Percival, however, is of the opinion that these are not club wheats but belong to the species *T. sphaerococcum* which he designated by the common name of Indian dwarf wheats. These are said to occur in the western districts of the Punjab, and to a small extent in the Central Provinces and in the United Provinces. These types are characterized by very short and compact heads; the grain also is much shorter than that of common bread wheat.

*The wheat area*—The wheat area in India may be roughly divided into two portions: (1) the alluvial soils of the Indo-Gangetic plain, where the bread wheats are commonly grown, and (2) the black cotton soils of Central India, the Central Provinces and Bombay where the macaroni wheats are mostly grown. The type of wheat more recently recommended by the agricultural departments, for the different wheat areas, are the following:—

i. In the Punjab area.

Punjab 8A—This has been a standard wheat of the Punjab, for almost a quarter of a century. In the early stages, the growth of this wheat is decumbent, that is, not erect as 9D. The grain is amber-coloured and very plump. It is a bearded wheat with grains which are moderately hard. It is also a good tiller, and, when ripe, does not shatter the grain easily.

Punjab 9D.—This is a fully bearded wheat with white awns and white pubescent glumes. Its growth in the early stages is erect. It is an early wheat, ripening about a week earlier than 8A. It, however, possesses weak stems and is therefore likely to lodge in conditions where there is plenty of moisture, and also where the fields are rich in



nitrogen. It does not tiller as well as 8A, which necessitates a higher seed rate.

During the last few years the Punjab Agricultural Department has put out two very promising crosses known as Cross 518 and Cross 591. These are also bearded wheats and have been found to do quite well, and in certain cases were better than the two standard wheats of the Punjab mentioned above. It has, however, to be seen yet how far these wheats can replace the other two wheats of the Punjab.

## 2. In the United Provinces.

Cawnpore 13—This is a standard wheat of the province, and has been distributed by the Agricultural Department since 1926. It is a bearded wheat, and a fairly heavy yielder.

Imperial Pusa 52—This is the product of a cross between Pusa 6 and Punjab 9. It is a bearded wheat, fairly high-yielding and fairly resistant to rust. This type possesses white glumes which are glabrous, and also white awns. The spike is somewhat loose at the base but more compact towards the apex.

Imperial Pusa 4—This wheat was produced by selection from indigenous forms. It is a beardless wheat, stands well, and is fairly rust-resistant. Its glumes are white and pubescent, a character which distinguishes it from Pusa 12 which is similar to it, but which possesses reddish glumes which are glabrous.

Imperial Pusa 12—This wheat is beginning to lose its popularity in this province.

During the last few years other wheats have been tried with some success in certain parts of the province. They are Imperial Pusa 111, Imperial Pusa 165, Punjab 8A, and Cross 518. They are, however, under further trial

before they can be generally recommended to cultivators in different parts of the province.

3. In the Central Provinces, A 115, more commonly known by its trade name of *sharbati*, is the most popular wheat in the province where *pissi*, a bread wheat, is being grown. This is a wheat with a relatively strong straw and fairly hard grains. It is also claimed to be less susceptible to rust than most of the other wheats of the province. In 1933, however, this wheat also suffered very badly from an attack of rust.

4. In Bihar, Imperial Pusa 52 for several years has been the most popular wheat. In recent years Imperial Pusa 165, an awnless variety, and Imperial Pusa 113 have been found to even do better than Imperial Pusa 52 in certain parts of the province.

5. In Central India and Rajputana both species of wheat, the durums and the bread wheats, are grown. Rajputana is more suitable for the wheats grown in the Punjab. Thus Punjab 8A, Cross 518, and Cross 591 have been found to do fairly well in certain parts of Rajputana. On the other hand, in the Malwa plateau of Central India, the local types of wheats have, in general, proved superior to the imported varieties. The bread wheats grown in the Malwa plateau are represented by the *pissi* types, and the durums by the Malwi types.

6. In Sind, four types of wheat are now being distributed by the Agricultural Department. Two of these are local selections, and the other two are imported varieties. They are C. Ph. 47, A. T. 38, Punjab 8A and Imperial Pusa 114.

7. In Bombay Presidency a new strain of wheat known as Bansipalli 808, a macaroni wheat, has been released by the Department of Agriculture for the Nasik district. It was obtained from a Cross between the improved Bansi strain 168, and Kala-Khapli 568, and ripens about two weeks earlier than the local wheat and is claimed to be superior in yield and quality.

## CULTURAL METHODS

*Preparation of seed-bed*—An ideal seed-bed is one in which the soil has been thoroughly pulverized and then compacted. That is, the lumps are crushed, but not to the extent of forming a dust mulch, as this generally forms a hard crust on the surface if rain occurs. This crust may prevent the seedlings from penetrating the surface soil.

The method of preparing a seed-bed in this country varies in general with the soil conditions, and also depends on whether the crop is irrigated or non-irrigated. In the alluvial soils, that is, in the Punjab, the United Provinces and Sind, the usual method of preparing a seed-bed is by repeated ploughing and cross-ploughing until the soil is thoroughly pulverized. In some cases a farmer ploughs as many as fifteen times. But the more common practice is to plough from eight to ten times. These repeated ploughings are usually done during the monsoon, with only one or two ploughings following the monsoon during the months of September and October. After the monsoon is over, the ploughing is usually followed by operating a beam or planker which is known as the *sobaga* in the Punjab and *patela* or *pata* in the United Provinces. When the crop is grown under irrigation, the number of ploughings is much less, usually two or three. This is, however, always followed by a planker in order to crush the lumps.

A better method of preparing a wheat seed-bed is to grow a green-manuring crop, and to plough it under with an improved mould-board plough before the end of the monsoon rains. One more ploughing with an improved plough, followed immediately by harrowing and planking completes the seed-bed preparation.

In the black cotton soil area, that is, in Central India, Bundelkhand, the Central Provinces, and Bombay, the practice is quite different from that in the Indo-Gangetic plain. Instead of a plough, a *bakhar* is used in the prepa-

ration of the seed-bed. This is an implement typical of this area and consists of a blade about twenty inches long and four inches wide, fixed at both ends to a beam of wood. It penetrates the soil to a depth of about 8 inches and pulverizes it. This makes the operation of planking or beaming unnecessary. The bakhar is usually operated during April or May and once or twice during the monsoon and again in September. The land is cultivated again with a bakhar in October previous to sowing.

*Date of Sowing*—Sowing usually begins about the middle of October and continues to the middle of November. This period of sowing is general throughout the country except in the North-West Frontier Province and adjoining parts of the Punjab, where the date of sowing is a little later than in the other wheat areas of the country.

*Method of Sowing*—Wheat is sown in three ways: (1) broadcasting, (2) dibbling, and (3) drilling. Broadcasting consists of scattering the seeds by hand, usually followed by harrowing or ploughing in order to cover the seed. This method is very inefficient and usually requires more seed per acre than the other methods. The seed also is not deposited at a uniform depth. Often many seeds are left on the surface where they cannot germinate. They may therefore be picked up and eaten by birds. The seeds also are not uniformly distributed over the field. Hence this method of sowing seed is not to be encouraged. However, this practice is followed, to a certain extent, in all parts of India where wheat is grown. It is probably less objectionable when the surface of the soil is moist. The amount of seed required per acre by this method varies from 40 to 50 *seers* (a *seer*=2 lbs.)

“Dibbling” consists of dropping the seeds by hand into the furrows that have been opened by a plough, the sowers usually following the plough. Dibbling is generally done by the women and children of the family, while the man ploughs. This method is less objectionable than broadcasting, but is more laborious and covers a smaller area per day. After dibbling, planking becomes necessary in order

to cover the seed, although this is sometimes done by the feet of the sowers which slows down the sowing operation. The quantity of seed required per acre by this method may vary from 30 to 40 *seers*. This method is sometimes used in the canal colonies of the Punjab and certain parts of Bombay on irrigated land.

The method of drilling wheat varies in different parts of the country. In the United Provinces and the Punjab, drilling consists of dropping seeds into a bamboo tube fastened to the plough in such a way that the seed drops just behind the point of the plough, in the bottom of the V-shaped furrow. The seed is partly covered by soil falling back behind the plough. Usually two persons are required for sowing by this method, one person driving the bullocks and operating the plough, while the other drops the seed into the funnel-shaped mouth of the tube. The seed is usually dropped by a woman. The depth of sowing can be varied by adjusting the bamboo tube. At the ends of the furrows blanks are apt to occur due to the turning of the bullocks. This is therefore corrected by sowing a few rows across the field to fill up these blanks. The quantity of seed required by this method varies from about 25 to 30 *seers* per acre.

In the Central Provinces and Berar the seed is sown by means of a three-coulter drill known locally as the *tifan*. In this implement three hollow tubes are attached, one to each drill, which meet at the top in a large wooden funnel. The seeds are dropped into this funnel by hand and are distributed in the three tubes. Thus this drill can sow three furrows at a time. The quantity of seed sown per acre by this drill is about 30 *seers*.

In the Bombay Presidency a heavy two-coulter drill is used, which is similar to that used in the Central Provinces. The seed rate by this drill is about 25 to 30 *seers* per acre.

Another type of machine which is being used more and more in this country for the sowing of wheat is a drill introduced from western countries. This drill varies in

size, depending upon the power used for drawing it. As bullocks are used in this country for draught purposes, smaller types are used. Such types can generally sow about five or six rows at a time. Therefore the area covered by these drills is much greater than that covered by local types. The machine is efficient as it distributes the seed uniformly at a proper depth. It works well only in case the seed-bed is in excellent condition.

As a comparison of these different methods of sowing, it may be said in general that drilling is more efficient than either "dibbling" or broadcasting, and it produces an increased yield. This increased yield is due to the fact that seed is sown at a uniform depth, making germination more or less uniform. Drilling also requires less seed per acre for sowing. Wheat seeds should be sown at the proper depth, as the permanent roots are always produced at about the same distance below the soil surface, regardless of the depth at which the seed is sown. When the grain germinates, three or more roots are produced. In the early stages in the development of the plant, the permanent root system is produced above the primary roots from the "crown" and these always develop within an inch or two of the soil surface. Hence if the seed is planted too deep the distance between the seed and the crown becomes unnecessarily long, and much of the energy derived from the seed is then wasted in the process.

*Cultivation after sowing*—After the seed has been sown, very little is done in the way of hoeing and cultivating, especially when the wheat is sown under dry-farming conditions. If it is grown as an irrigated crop, the land is divided into small compartments or *kjaris* for purposes of irrigation. In the Punjab, this is done before the germination of the seed, by means of a *jandra*, a large wooden rake. The number of irrigations given to the crop varies according to the soil conditions and climatic factors of the locality. In the Punjab the number of irrigations after sowing is generally two or three or more.

In the United Provinces it may vary from one to three. In certain parts of Rajputana the number of irrigations may be as many as six.

The wheat crop is usually not weeded except by the best cultivators. The most troublesome weeds in the wheatfields in the Punjab as well as in the United Provinces, are *bathua* (*Cenopodium album*) and *piazi* (*Asphodelus fistulosus*). The wheat crop is sometimes subject to "lodging" or "laying" of the crop. This phenomenon is caused by the weakness of the straw, or of the root-system, and is generally brought about by an excess of moisture in the soil, or its high fertility. If the crop bends down at the early stages of its growth, the plant may again stand upright due to the geotropic stimulus to the plant. But if it takes place late in the growing season, the crop will usually remain flat on the ground. Wheat will usually lodge when subjected to heavy rain accompanied by high winds and hail.

*Harvesting and threshing*—The harvesting of wheat begins in March in the Central Provinces and parts of Central India. In the United Provinces wheat is usually harvested in the latter part of March and up to the middle of April. In the Punjab the harvest usually begins about the middle of April and extends into May. In the North-West Frontier Province the harvesting season is much later, starting about the beginning of June and is not generally over till the end of that month.

Wheat is generally harvested by cutting with a sickle, a small hand implement known as the *hansia* in the United Provinces or *daranti* in the Punjab and Central India. After the crop has been cut, it is tied into bundles and carried to a central place and stacked. The crop is usually fully mature and therefore can be threshed immediately.

Threshing is generally done in most parts of the country by treading with bullocks. The wheat is spread on a threshing floor, which is generally made of earth. The bullocks are driven round and round until the grain is separated from the chaff. The final separation of the grain

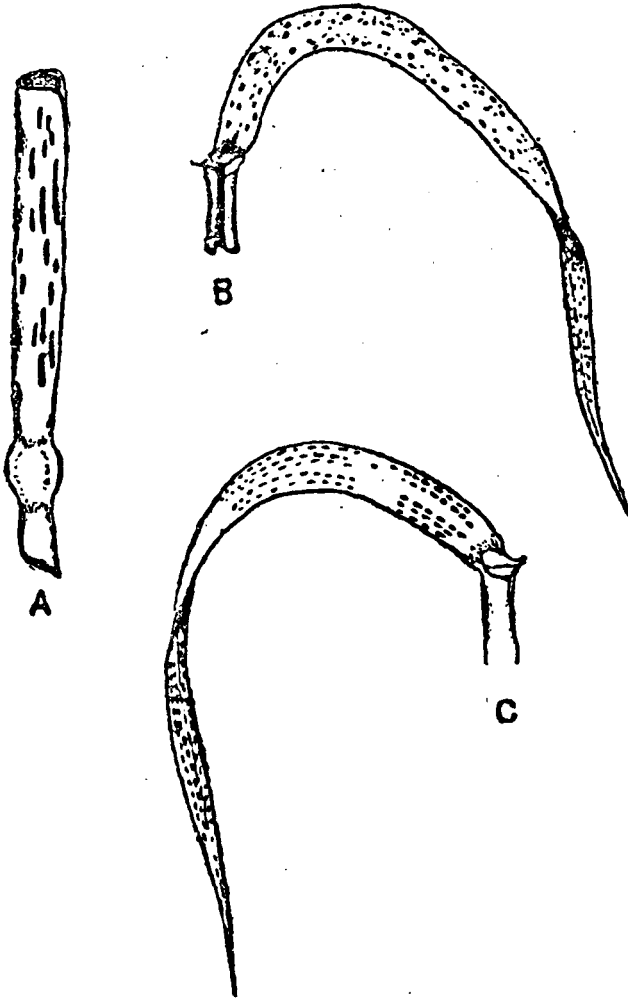


Figure 3. Rust diseases of wheat

A, *Puccinia graminis* or black stem rust; B, *P. triticina* or orange rust; C, *P. glumarum* or yellow rust.



from the *bhusa* or broken chaff is done by winnowing from a basket which is known as a *sup* or *chhajj*. The basket is held high over the head and is shaken, allowing the *bhusa* and grain to drop from the basket slowly to the ground. The steady winds which generally prevail at this time of the year separate the *bhusa* and dust from the grain. The *bhusa*, being lighter, is carried further away than the grain.

After threshing, the grain is stored either loose or in bags in rooms. Sometimes it is stored in mud bins. These are of several types, varying in different parts of the country. The grain which is kept for home consumption or seed purposes is generally stored in mud bins known as *khuttis* when dug in the ground, or *kothis* when above ground. Sometimes earthen jars (*bharolas*) are also used for storing wheat which is to be used in the home.

Grain intended for sale is generally disposed of to buyers soon after threshing.

#### DISEASES AND PESTS.

*Rusts.*—Rusts are the most serious diseases of wheat in India. The occurrence of these rusts on the wheat crop greatly reduces the yield. Even if the loss due to rusts is put at a very conservative estimate of about five per cent, the loss to the country on the whole would amount to several million rupees annually.

Three kinds of rusts generally occur on the wheat crop in India. These are known as orange rust, caused by *Puccinia triticinia* Erikss., yellow rust, caused by *P. glumarum* Erikss., and black rust, caused by *P. graminis* Pers.

Orange or brown rust is the earliest to appear on the wheat crop. In Bihar it sometimes appears as early as November, but more often the attack begins at the beginning of the year. This rust attacks the leaves almost exclusively, but may appear also on the sheath and very rarely on the stems. It may be distinguished from the yellow rust by the fact that its pustules are not arranged in re-

gular order but scattered on the leaf in an irregular fashion. The pustules are bright orange when fresh, but when old are similar to yellow rust. They occur usually on the upper surface of the leaf.

Yellow rust usually appears later than the orange rust but earlier than the black rust. It attacks the leaves most severely but also, in severe cases, leaf sheaths, culms and even ears. The rust appears in long rows of pustules which are small and oval, and are lemon yellow in colour. The pustules remain covered in the epidermis for some time; but on bursting, a yellow powder is shed.

Black rust attacks the stems most severely, then the sheath, the leaves, and the ears. It has sometimes been called for that reason the black stem rust. This is the last to appear, usually about the month of March in northern India. The pustules are large, elongated, running together and bursting early. In bursting it breaks up the epidermis into large fragments, and exposes a brown powder which, as the season advances, changes to black. It is found in all parts of the plant, but least on the leaf blade.

These three types of rust occur in the United Provinces and Bihar every year. All these may sometimes occur on the same plant. In Bombay and in the Central Provinces orange rust does not usually occur except in years of very severe rust attack. In the Punjab also this rust is not as common as the other two. Black rust is not considered as destructive in India as in some other countries such as Australia and the United States. In India yellow rust is probably responsible for the major damage done to the wheat crop.

The occurrence of rust epidemics depends on several factors, such as rain, high humidity, over-irrigation, and a thick stand which produces a high humidity of the air within the crop itself. The manner in which rusts appear annually in the plains of India has not been satisfactorily explained. Several views have been advanced to explain this annual outbreak of rust. These may be briefly enumerated as follows:

1. According to one view, which is commonly accepted in America it is believed that the barberry bushes (*Berberis lycium* and *B. aristata*, etc.) which grow wild on the Himalayas, are the host plants which harbour this parasite during the hot summer and that spores from these plants spread to the plains during early winter and infect the crop.

2. The parasite is harboured during the summer by stray volunteer plants of wheat, which may naturally grow during the rainy season following the hot weather.

3. The parasite lives on some other grass during the summer months.

4. The parasite lives in the soil until the new crop is ready for infection.

5. The parasite lives in the protoplasm of the grain cells, and when conditions become favourable it appears on the external parts of the plant.

Extensive researches carried on under the Imperial Council of Agricultural Research seem to indicate that rust outbreaks in this country are brought about by the dissemination of spores from centres of infection which are located at higher altitudes, such as the Siwalik Range in the United Provinces, the Murree hills in the Punjab, the Western Ghats in the Bombay Deccan, and the Nilgiris and the Palni hills in Southern India.

This disease cannot be controlled by direct treatments. The best method for combating it is the growing of varieties of wheat which are resistant to rust. A few such types have been produced, which are claimed to be resistant to certain physiologic forms of rust. Of the Imperial Pusa varieties, I.P. 114, I.P. 120, I.P. 125 and I.P. 165 have been claimed to be highly resistant to one form of orange or brown rust.

*Loose smut* (*Ustilago tritici*)—This disease is quite common in the wheat-growing provinces of India, especially in the Punjab. It very seldom becomes epidemic and therefore, ordinarily, does not do much damage. The

ears of the infected plants are black, the black powdery material being found in place of the grains. These masses of black powder are covered with a thin membrane which sooner or later bursts, exposing a dark powdery mass of spores which are blown off by the wind, leaving a bare rachis behind.

Infection takes place during flowering; the spores falling on the flower germinate and enter the developing grain. The fungus lives inside the grain until the seed is sown. After the seed germinates the fungus develops along with the plant and produces its spores in the place of the wheat grains.

Several methods of controlling this disease have been devised, but the simplest and one which can be easily adopted in Northern India is known as the "solar energy method". In this method the seed is soaked in water for about 4 hours in the morning, say from 8 a.m. to 12 noon, on any bright summer day. The seed is then taken out and spread in the sun for four hours, that is, from 12 noon to 4 p.m. When the seed is thoroughly dried it is stored until sowing time. By this treatment the fungus inside the grain is killed by the light and heat from the sun whereas the grain remains unharmed.

*Bunt or stinking smut (Tilletia sp)*—This disease does not appear to be common in the plains of India but occurs in parts of Baluchistan and the Western Himalayas, extending into the Punjab, and is very common in Kashmir. The disease in India is caused by three species: *Tilletia caries*, *T. foetens* and *T. indica*. The first two are confined to the cooler regions, whereas *T. indica* is more or less confined to the plains. Plants affected by this disease possess ears which are of darker green colour and more open than the normal ones. The plants also mature more rapidly. The ears thus contain a black mass of spores which stink like rotten fish. The black mass is, however, kept intact and not blown away by the wind as in the case of loose smut. The disease spreads by the spore-balls becoming ruptured during harvesting and threshing, and the spores coming in

contact with sound grains. The spores adhere to the grains and germinate when the seed is planted, entering the plant through the tender tissue of the wheat seedling. The fungus develops along with the plant and produces its spores in the place of the grains of wheat.

The disease may be controlled by several methods. The earliest method adopted was to steep the grain in dilute formalin solution. The solution is made of one pound of commercial formalin (about 37 per cent formaldehyde) in forty gallons of water. This is sufficient to treat 80 maunds of grain. The grain should be covered with moist gunny bags for about two hours and should be sown preferably within twenty-four hours.

Another method used for treating this disease consists in the use of copper compounds, such as copper sulphate, and copper carbonate dust. Experiments have shown that copper sulphate injures the grain, thereby reducing the germination, and that copper carbonate dust is more effective. When copper carbonate dust is used, the grain is thoroughly dusted with it. This is usually done by sprinkling the dust on the seed followed by repeated turning of the seed until every grain of wheat has a coating of the carbonate dust. In doing this one should be careful not to inhale the dust as it is poisonous. This may be avoided by tying a cloth over one's nose and mouth.

*Minor diseases*—Certain other diseases have been reported to attack the wheat crop, but their damage is slight and they are therefore of little economic importance. Among these are (1) a leaf spot disease caused by *Helminthosporium tritici-repentis* Died, reported from Pusa in Bihar (2) a foot-rot disease (*Helminthosporium* sp.) reported from the Central Provinces, and (3) a root-rot disease caused by *Pythium graminicolum*, reported from the Bombay Presidency.

*Insect pests*—Among the numerous insect pests which attack the wheat plant, the wheat stem borer (*Nonagria uniformis*) is one which does the most damage in this country. This insect at one stage of its life

is a caterpillar and it is during this stage that it is very destructive. The full-grown caterpillar is about one inch long, smooth, with a brown head and a rather pinkish body. The caterpillar bores into the stem of the wheat plant, feeding on the centre of the stem. In the adult stage this insect is a moth. The insect may be controlled to some extent by destroying all the withered plants which have been attacked by this pest.

Another common insect pest which attacks the wheat crop is known as the aphid. The insect attacks the leaves and ears of the wheat plant. No practical remedy has been suggested for the control of this insect, although spraying will control it to some extent. The insect is also controlled biologically in nature by certain insects known as lady-bird beetles, which flourish at the time when aphides occur.

*Insects of stored grain*—Wheat stored for consumption or seed purposes is often attacked by insects. These insects attack the grain at different stages of their life-history and, in extreme cases, reduce the grain into flour and dust. The most common of these stored grain pests is probably what is known as the rice weevil (*Calandra oryzae* L.) This is a small dark-coloured weevil about one-eighth of an inch long with a prominent curved snout. It lays its egg on the wheat grain, one female laying about 400 eggs. The eggs are hatched after six or seven days. Each larva bores into the grain with its strong teeth and eats out a large portion of the grain, forming a cavity in which it lies. The insect completes its life cycle in about a month, and there are three or four generations in a year.

Another common insect pest of stored wheat is what is known as *khapra* (*Trogoderma khapra*). The adult is a small active brownish-black beetle. The female is bigger than the male. The adult lives only for a few days. The whole life cycle is completed in about a month in the summer, and there are usually four generations in a year. The female lays the eggs singly on wheat grains. One female lays from 35 to 60 eggs. The eggs hatch in

about five to seven days. The grubs are usually small, brownish and with long hairs on their body, specially at the posterior, and they feed on the grain and grow bigger. The grubs are very active in the summer and abound in the upper layer of the infected grain heap and cause the greatest damage in the top six to twelve inch layer. The adults are harmless, the grubs doing all the damage. The grubs eat the grain and the attacked portion appears whitish. In extreme cases of attack, the grain is reduced to flour and dust. The damage is usually continuous and gradual, as the insect multiplies slowly.

The most common method of controlling these stored grain pests is by fumigating with carbon bisulphide of a proper strength for a definite period. Grain exposed to the fumes of carbon bisulphide at the rate of one ounce per 15 cubic feet of space for 24 hours, or 2 to 5 lbs. for 1,000 cu. ft. will be free from all insects, even the eggs of the insects being killed. The grain can be removed, and after the fumes are allowed to evaporate the grain can again be stored. The carbon bisulphide is an inflammable liquid, and therefore care should be taken to see that no fire is brought near it.

Fumigation by Cyano dust at the rate of 2 lbs of dust for 1,000 cu. ft of the go-down is also effective in controlling these insects. But the hydrocyanic acid gas emitted by this dust is a very strong poison and should be handled only by those who are acquainted with the method.

In order, however, to prevent the infestation of the grain with pests it is very desirable at the outset to see that the grain is free from all infection. That is, seeds that are already infested with insects or which carry eggs of insects should never be stored.

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CHAPTER III

RICE

*Introduction*—Rice is one of the most important crops of the world. Its culture began in the unknown past. Evidence tends to show that rice culture began in south-eastern Asia. It is now the staple food of most of the people of China, Japan, India, Indo-China, Java, Siam and Korea. It is also grown to some extent in Italy, Spain, Egypt and many other countries of the world. The Indian crop of rice constitutes 60 to 65 per cent of the world's production, excluding China from which no statistics are available. In India it is the most extensively grown crop, occupying every year about 80 million acres. It is, however, mainly confined to the wetter parts of the country.

*Distribution in India*—The distribution of rice in India according to provinces is as follows:

TABLE 5

Showing the distribution of rice according to Provinces and States.

Provinces and States	Area in thousand acres in		Yield in thousand tons in	
	1937-38	1940-41	1937-38	1940-41
Bengal .. ..	22,201	20,770	9,034	6,043
Madras .. ..	10,141	10,744	4,850	5,150
Bihar .. ..	9,513	9,210	3,144	2,134
United Provinces .. ..	7,004	7,292	2,017	1,806
C. P. and Berar .. ..	5,704	5,873	1,552	1,099
Assam .. ..	5,056	5,426	1,745	1,805
Bombay .. ..	1,867	1,970	860	802
Sind .. ..	1,231	1,420	519	427
Hyderabad .. ..	962	1,200*	368	360*
Mysore .. ..	707	750*	220	230*
Orissa .. ..	5,060	5,069	1,623	1,339

\* approximately.

Thus Bengal stands first among the rice-producing provinces of India, the acreage being approximately 25 per cent of that of the whole Indian Empire. The next in order of production are Madras, Bihar, the United Provinces, Orissa, the Central Provinces and Berar.

*Botanical description*—The rice plant (*Oryza sativa* L.), like wheat, is a member of the grass family. The common cultivated rice is an annual plant which thrives best under swampy conditions. The plant usually grows to a height of 2 to 6 feet, but there are certain varieties which grow much taller. The plant stools freely, that is, it produces several stems or culms in one plant. At the axil of each leaf a bud is produced which may develop into a tiller. Ordinarily this occurs only from the buds at the base of the plant, where the internodes are usually very short. All the culms therefore appear to arise from the same place. Usually a tiller possesses fewer leaves than the main stem. If a secondary branch arises from a primary one (that is, a branch arising directly from a main stem), then the number of leaves of the secondary branch are less in number than those of the primary one.

The rice culms are usually hollow except at the nodes, but when the stems are short the internodes also may be solid. Some deep-water rices have one characteristic feature, and that is that their stems grow with the gradual rise of the flood-water level.

The rice leaf is similar to that of wheat, but is usually distinguishable from it by the length of the ligule, a scale-like structure which appears as a continuation of the sheath, and at the junction of the blade and the sheath. In the rice plant this structure is very prominent and is longer than in any other cereal. It is usually more than 1 cm in length, acute or obtuse in shape, and is usually divided into two parts, by a suture from the base to the apex.

The inflorescence is a panicle. The spikelets which make up the panicle are one-flowered and laterally compressed. The lemma and palea are similar in size, but the for-

mer is five-nerved, whereas the latter is only three-nerved. Both may or may not possess awns. The lemma and the palea together are known as the "hull," and rice enclosed in the hull is known as "paddy." The rice flower contains six functioning stamens, which distinguish it from the other common cereals.

Rice is usually self-pollinated, though natural cross-pollination occurs to a more limited extent. The pollinating habit of the rice plant varies with the variety and also with environmental factors such as wind, temperature, moisture and light conditions. Sometimes pollination in the rice flower may take place even before the opening of the flower, thus making artificial cross-pollination of rice difficult. The wild rice of the Central Provinces and Berar, as a rule, does not discharge the pollen until a few minutes after the extrusion of the anthers. In these rices natural crossing occurs in about 7.9 per cent of the cases.

The presence or absence of an awn is a hereditary character, although its length may be affected by environmental conditions. The presence of awns in rice as in wheat is considered an advantage as such rices are less subject to bird attacks.

The rice grain is of various textures, colours, sizes and shapes. Some varieties possess semi-transparent grains, others starchy, while in others the grain may be purplish black. The grain colour is often used to determine the quality and also the variety. Usually rice with little or no red grain is preferred to one containing red colour. Although slender rices are usually preferred by consumers, millers prefer the thicker ones as these do not break so easily in milling. The rice grain is botanically known as caryopsis.

The root system of rice is fibrous. Many of the roots are in whorls, arising from below the nodes. These roots grow through the sheaths of the dead leaves extending in all directions. The depth to which these roots extend varies from 6 to 18 inches, but they are more shallow in moist ground than in dry soils. Adventitious roots are

sometimes produced from the first three nodes above the ground. These usually arise due to the receding of flood water, thus enabling the plant to support itself.

Rice consists of a vast number of varieties which differ markedly in their demands upon, and response to, the environment. Its culture is mainly confined to the humid regions of the tropics. It does not grow well at low temperatures. It is able to make use of the ammonium nitrogen better than the nitrate nitrogen.

Rice has been grown in the Himalayas up to 7,000 feet. Different varieties of rice, however, can stand different temperatures. It is for this reason grown to some extent in several parts of India, where it is not commonly grown, such as in Kashmir and the Punjab.

The rice plant generally requires a heavy type of soil, usually clay loam to clay, although it is known to do well on loam where sufficient water is available. Evidently, water is a limiting factor in the production of the major crop of rice. On this account, for rice culture, a soil underlaid with a more or less impervious stratum should be preferred.

*Classification*—The rice plant possesses a very high degree of physiological adaptation to particular ecological factors, which is responsible for the fact that there are in cultivation several thousand different varieties of rice. According to Copeland, there are in India 8,000 varietal names given to probably different varieties of rice. But the number of distinct varieties is probably less, as the same variety may be given different names when grown in different localities.

The first attempt in the classification of rice in this country was probably made by Roxburgh, who believed that the cultivated rices originated from the Indian wild forms which he found in Madras, Orissa, Bengal, the Arakan hills in Burma and Cochin-China. Roxburgh adopted a system of classification of rices based on their peculiarities of cultivation—the early and late rices.

Duthie and Fuller (1882) in classifying the rices of the United Provinces divided them into three classes. The first consists of those with a tall habit of growth, with protruded and drooping ears, and with a yellow-husked grain. The second group consists of those with shorter habits of growth, with ears not so prominent but more or less erect, and with thick yellow or red-husked grain. The third group is made up of rices with short strong stems with the ears partially enclosed in the sheath and grain-husks dark-coloured or black. Hooker and Watt also made further attempts at classification of not only the wild rices but also the cultivated ones.

Gammie working in the Bombay Presidency made use of the average number of tillers in order to sort out the different varieties in the province.

Outside India, the first serious attempt at the classification of rice was made by Kikkawa (1912) in Japan, who used both the morphological and agricultural characters for separating the different varieties.

Graham (1913), working in the Central Provinces, classified the rices of that region into two main divisions: (1) rices with coloured leaf sheath and (2) rice with green leaf sheaths. Then he further sub-divided each group into two sub-groups by the colour of their grain, that is, whether red or white. Each sub-group was further divided on the basis of the (1) vegetative characters, (2) the character of the spikelet, and (3) the character of the grain. In this way, Graham was able to sort out 100 different varieties of rice in the Central Provinces.

Thadani and Durga Dutt (1928), in working with Sind rices, divided them into two main groups: (1) bearded and (2) beardless, that is, on the presence or absence of awns. The two main groups are further sub-divided on the basis of (a) colour of leaf sheath—green or red, (b) colour of grain—white or red, (c) character of grain—long, fine or coarse, (d) colour of inner glumes—white, yellow, red or black, (e) colour or lack of colour of the tip of inner glumes,

(f) colour or lack of colour of the outer glumes." Thus Thadani and Dutt classified the rices of Sind into 35 different types.

Sethi and Saxena (1930), working with the rices in the United Provinces, followed Kikkawa's system of classification, using both the morphological and agricultural characters for separation of the varieties. The system makes use of the character of the grain, such as its colour, size and shape. The different varieties, one hundred and thirty-five in all, were then described by the character of the hulled and unhulled grain.

Mitra and Ganguli (1932), in classifying the rices of the Surma Valley in Assam, used the characters of the unhusked grain for separating the varieties. The varieties were divided into two groups: (1) awned and (2) awnless. These were further sub-divided according to the character of the kernel, that is, coarse, medium or fine, and whether they are glutinous or non-glutinous; and further, whether the kernels are long, intermediate or short, and whether white, amber or red. The character of the inner glume is then used to further sub-divide the varieties, on the basis of whether it is yellow, brown, black or mottled. These workers in Assam were able to classify the rices of the Surma Valley into 95 different varieties which are made up of 703 types.

Hector and his associates in Bengal made several attempts at classifying the rices of the province. The results of these efforts have been published from time to time since 1916. In his last classification published in 1934, all the varieties were separated into five main groups: (1) translucent, (2) glutinous, (3) winged, (4) clustered and (5) double-grained. These groups were further sub-divided according to whether the spikelet is awned or awnless, and whether the leaf sheath, tip and stigma are coloured or colourless. "Within varieties... types are further grouped into highland *Aus* and transplant *Amans*, according to date of sowing and harvest, and each of these again into early, medium and late, according to duration from sowing to

harvest". Thus Hector and his associates separated out 540 different varieties of rice in Eastern Bengal.

Kashi Ram and Chetty (1934), working with Bihar and Orissa rices, based their classification mainly on morphological characters. The rices were divided into two groups based on the constitution of the rice grain, that is, whether it is glutinous or starchy. Then they are further sub-divided according to (1) the length of the outer glumes, (2) the presence or absence of clustering in spikelets, (3) the length of the internodes, (4) the colour of the inner glumes, that is, whether brown, purple, black, olive, gold or straw-coloured. Thereafter (1) the colour of the apiculus, that is, whether it is colourless, purple or brown; (2) the colour of the outer glumes which may be white, brown and purple; (3) the colour of the kernel which may be white or red and (4) the colour of the internodes, whether green, gold or purple, are all used for further separation of the varieties. Finally the grain size and shape are used for separating the ultimate classes. In this way these workers sorted out 123 different varieties of rice in Bihar and Orissa.

Kashi Ram and Ekbote, in 1936, published another classification of the autumn rices of the Punjab and the Western United Provinces, using the same scheme used by Kashi Ram and Chetty in Bihar and Orissa. In this classification 41 different varieties of rice were sorted out.

Some other workers have started to classify rice from a genetical relationship, more particularly on the cytological evidence. Kato and his colleagues, working in Japan, have divided all the cultivated rices of the world into two types: (1) *japonica* which is indigenous to Japan and Korea, and (2) *indica* which is indigenous to India, China, Java, south-eastern Asia. Thus the two groups may be called "temperate" and "tropical" rices. Cytological evidence shows that there is some difference in the nuclear structure as well as in the sizes of the chromosomes of the two groups. It has also been found by the above workers in Japan that there is some chromosomal incompatibility



between the two groups. This is also supported by the work of Jones on Japanese and Chinese rices in California.

These different classifications evolved may serve as guides to the identification of the rices in the respective regions. But before a complete varietal classification can be made, a more detailed study of the cytological phenomena of the rice plant is required. It is also desirable that a complete botanical and agricultural survey of the existing varieties in India be made, before such a classification is possible. This can perhaps be done best by the establishment of a central rice research institute at some suitable locality. At such an institute all the varieties can be collected and grown for this purpose.

#### CULTURAL METHODS

*Methods of Sowing*—While rice is sown in different parts of India, or even in the same regions, in different months of the year, yet the main bulk of rice is made up of the crop usually sown by broadcasting in April to May and usually known in Bengal as the *aus* "highland" rice, and another sown in June and July and usually transplanted into standing water in July and August and usually known in Bengal as *aman* "transplanted" rice. Besides these two major crops of rice, there are three others known in Bengal as the lowland *aus* rice, the lowland *aman* rice and the *boro* or spring rice. The following table shows more graphically the different agricultural characteristics of these five groups:—

TABLE 6

Showing the Agricultural Characteristics of Certain Groups of Rices.

<i>Groups</i>	<i>Sown</i>	<i>Transplanted</i>	<i>Harvested</i>
<i>Aus</i> highland	April-May	Not transplanted.	Aug.-Sept.
<i>Aman</i> transplanted.	June.	July-August.	Nov.-Jan.
<i>Aus</i> lowland.	February-March	Not transplanted.	Aug.-Sept.
<i>Aman</i> lowland	February-March	Not transplanted.	Dec.-Jan.
<i>Boro</i>	October.	December.	March.

In Bihar and Orissa as well as in Assam the number of seasonal crops of rice is more or less similar to that of Bengal.

In the United Provinces there are usually three crops of rice. The first is sown broadcast in the beginning of the rains in July. This crop occupies about 65 per cent of the rice area in the province. The second is transplanted rice, and is generally sown in the nursery in the first week of June and transplanted about a month later when the plants are about a foot high. This crop occupies about 35 per cent of the total area under rice in the province. The third crop is known as marsh rice and is equivalent to the *boro* in Bengal. It occupies a small percentage of the total area under rice in the province. The seed for this crop is sown in nurseries in the months of December and January and transplanted in February. It is commonly grown on the margins of lakes or ponds. The crop is harvested in May and June. This is therefore a *zaid* crop. The rice of this crop is usually considered to be of a poor quality.

When rice is broadcast, the land is generally prepared by ploughing and cross-ploughing as early as possible, preferably in the early winter before the soil gets too dry. When the early rain sets in, the soil is cultivated with a bakhar to pulverize the soil and to keep down the weeds. The clods are also sometimes crushed by means of a beam. When the monsoon sets in, the seed is broadcast or, better still, drilled into the soil to a depth of one or two inches.

When rice is transplanted, the seeds are first sown in the nursery, which is located where water is easily available. The seed-bed is also prepared in a similar way as for broadcasting, but more care is taken in the preparation of the nursery as it is very important that the plants should have a good start. Usually the nursery is located on lighter soils so that the roots of the rice seedlings are not too seriously injured when removed from the soil for transplanting. One-tenth to one-twentieth of the area to be planted is required for the seed-bed.

When the seedlings are about nine inches high, they are taken up for transplanting to the field. Before the seedlings are planted in the field the soil is usually flooded and puddled. The seedlings are then pulled and tied in bundles for transplanting. The tops of the bundles are usually cut off before transplanting is done. This trimming lessens transpiration through the leaves and also prevents them from being blown over by high winds before they take root. The number of seedlings put in at one point varies from one to four. Seedlings that are put in early usually grow better than those that are broadcast or even drilled. The seedlings are planted in rows as far as possible. The distance between rows and between points in a row varies with the variety, the distance between rows being usually about eight to ten inches, and in a row from six to eight inches.

Transplanting is usually done by women who walk backward in the soft mud and place seedlings about one inch deep in it.

In some parts of the United Provinces instead of transplanting, sprouted seeds are sometimes sown broadcast on well-prepared puddled land.

The amount of seed necessary for one acre by broadcasting is about 30 seers; by drilling 20 seers; and for a seed-bed, three maunds per acre may be sown, and this will be enough for twelve acres.

*Care after Sowing*—When the crop is broadcast, usually no care is necessary until harvest, but if the fields are infested with weeds, ploughing is sometimes resorted to, when the plants are about a foot high. This interploughing not only destroys the weeds but also some of the rice plants. The operation, however, is beneficial in that it stimulates the tillering of the plants.

Transplanted rice does not need very much attention after transplanting, except to see that the plants receive plenty of water during the period of their growth. However, the process of draining off water from the ricefields every week has been found to increase the yield of rice.

Uniform ripening of the crop is also brought about by draining the water completely well ahead of ripening stage.

*Harvesting.*—This is usually done by cutting the plants with a sickle, as in the case of wheat.

*Aus* paddy is usually harvested before the plants become quite mature as they shed the grain more easily than do the *amans*, and also because the stems are more brittle than those of the latter. The crop is therefore cut while the plants are still somewhat green, and then left in the fields for about a week to dry before the paddy is separated from the straw by threshing. After the crop has been harvested, it is collected in a heap and sometimes it is threshed by beating with a flail, but more often the ears are separated and the paddy is trodden out by bullocks. After threshing, the husk remains attached to the grain. These are separated later by pounding with a pestle in a mortar. It is usually advisable to defer the husking for a few months in order to decrease the amount of breakage in the process.

Where there is a large quantity of rice to be husked, this is generally done by means of a rice huller driven by some type of mechanical power. There are now several types of rice hullers on the market.

#### DISEASES AND PESTS

While the rice plant is more hardy and not so susceptible to diseases and pest attacks as wheat, yet there are a few that are of some economic importance. Those that are fairly common will therefore be discussed here.

*Sclerotial disease (Sclerotium Oryzae Catt)*—This is probably the most common fungus disease in the rice-growing areas of India. The symptoms of this disease are not easily noticeable, and it is therefore generally overlooked. The fungus attacks the plants near the base of the stems, causing them to bear what is known as "light" ears; that is, the ears contain about fifty per cent or less of spikelets which bear light grains. The plants also throw out green shoots from the base when the rest

of the crop is maturing and turning yellow. If the plants thus attacked are examined carefully at the base of the stems, they will be found to be slightly discoloured at the lower internodes. If the stems are split at these internodes, a dark greyish web-like mass of hyphae is found within the hollow portion of the stem, and along with this, small round black shining bodies can be found all over the inner surface. These bodies are known as sclerotia. These sclerotia probably continue to live in the soil even after the crop is harvested. It is therefore extremely difficult to control a disease of this type.

*False smut (Ustilaginoidea Virens (Cke. Tak.)*—This is another fungus disease which commonly occurs in certain parts of India, such as Bengal and Bihar. The plants attacked with this disease appear to bear some large green swollen grains, which are about twice the size of the normal grain. If the swollen grain is opened, the substance inside will be found to be orange-yellow with a white mass towards the centre.

Usually the disease affects only a few grains in the ear, and these may be on any portion of it. Infection probably takes place during the flowering stage.

The disease is not yet completely understood and no control measure has been developed. However, the disease is not serious, and hence control measures may be impracticable.

*Bunt (Tilletia horrida Tak)*—While this disease is quite serious in some parts of the world, in India it has not been found to do much damage. The disease, however, is known to be sporadic in nature.

This disease attacks the kernels, but the size of the grain inside the husk may or may not be increased, but never to the extent that the husk will be opened. Inside the husk of these diseased grains, a mass of black spores occurs within a thin membrane, which when ruptured sets the spores free.

The disease is controlled in America by floating out the light grains in cold water. These grains are usually

the infected ones. The rest of the grain is then soaked for twenty-four hours in a solution of  $1\frac{1}{2}$  lbs liver of sulphur in 25 gallons of water, or by soaking the seed for two hours in a two per cent solution.

In addition to the above diseases there are some which have been reported to do considerable damage in some localities. The eelworm disease (*Ufra*) which is supposed to be caused by *Tylenchus angustus* is reported to have done a great deal of damage to rice in eastern Bengal. The life-history of the disease has not been completely worked out and is therefore not completely understood.

Another disease which has been reported from Madras is said to be caused by *Helminthosporium* Sp. The fungus forms dark-brown disease spots on leaves, leaf-sheaths and glumes. The disease spreads rapidly when weather conditions are favourable for its development.

*Rice hispa*—This is one of the most serious insect pests attacking the rice plant in this country. In the adult stage this insect is a black spiny beetle. It, however, does most of its damage in the larval stage. The damage done by this insect is mostly on the young seedlings in the seed-bed or shortly after planting in the fields. The older rice plants are less attacked and usually not injured. The female adult lays its eggs in the young leaves, one egg at a time being deposited in the tissue under the epidermis. From this egg a grub hatches out which feeds between the upper and lower epidermis of the leaves causing the spot to turn yellow and wither. The grub is white or yellow with black markings, and is much flattened. The grub when full grown, turns into a brown, flattened pupa, and emerges as a beetle.

The pest may be controlled to some extent by bagging. This consists of dragging systematically a cloth bag which can be made of a *dboti* held at two corners by two men. The beetles thus collected may be put in a pot containing water and little kerosene oil, so that they may die.

Another method recommended for controlling this pest is to drag a rope, across the field by two men holding

at each end, the rope having been previously moistened with water containing kerosene oil. This should be done once in the morning and again in the afternoon to disturb the beetles and prevent them from laying eggs on the leaves of the young plants.

*The rice leaf-hoppers* (*Nephotetix bipunctatus* Fabr., and *apicalis* Motsch)—These insects have been known to do considerable damage to the rice crop in the Central Provinces, Bihar and parts of Assam. They belong to a group of insects known as the Jassids, which are commonly found almost throughout India. These hoppers are small greenish insects which jump about from plant to plant. The adults remain on the lower surface of leaves mostly near the midribs sucking the juice during the hottest part of the day. Where the damage is serious, the fields appear blighted. These insects breed in succulent grasses in nurseries or near tanks, and begin to appear in large numbers in July. Heavy rains are unfavourable to their spread.

The adults are attracted to light, so the pest may be controlled by lighting small fires at night in several places in the fields. The insects will fly into the fire and burn themselves. These are usually noticed near the *Devali* festival when they fly to the *chirags* or small lamps in large numbers at night.

*The rice grass-hopper* (*Hieroglyphus furcifer* serv.)—This insect sometimes does considerable damage to the rice crop, by eating the leaves and the soft grains. The pest lives in the ricefields and occasionally in damp waste places or in sugarcane fields and generally appears in the months of August and September. It is a greenish or straw-coloured insect, which is found in two forms: one with long wings and another with short imperfect wings. But as the insect does not fly, the wings are apparently useless. The pest is commonly found in Bengal, the Central Provinces, parts of the Bombay Presidency and Mysore.

The insect may be controlled by bagging or by drag-

ging a net through the ricefields to sweep up the insect. Where the pest occurs every year, it is best to plough up the fields in April and May so that the eggs are killed by exposing them to dry heat. Also those birds that are known to eat these grass-hoppers may be encouraged by providing shelters for them in the ricefields.

*The rice bug (Leptocorisa varicornis F.)*—This is a slender green insect about three-fourths of an inch in length. These insects appear to be all legs and feelers with a long proboscis which reaches beyond the insertion of the hind legs. The insect possesses a peculiar odour. It does most of the damage to the rice crop by sucking the sap from the developing ears, causing them to turn white. The insect is commonly found in Assam, Bengal, the United Provinces and Madras.

The insect may be controlled by collecting in hand-nets or by bagging. The pest is controlled in nature by another insect known as the six-spotted tiger beetle (*Circindela sexpunctata L.*) which feeds upon the rice bug.

*The army worm of paddy (Spodoptera Mauritii B.)*—This insect is common in many regions where rice is grown. In India it appears to be more common in the southern parts of the country such as the Madras Presidency, Mysore and the Nizam's dominions. The young caterpillar appears at the early stages of the growth of rice and usually does a great deal of damage to seedlings in the nurseries. The full-grown caterpillars measure about an inch and a half in length. When the caterpillar is well fed it pupates and later develops into a moth. The insect is controlled in nature by birds and other parasitic insects. The pest is also controlled mechanically by sweeping the insects with brooms into baskets or hand-nets. In some cases the fields are flooded and the insects come out of the ground, and are then destroyed by birds.

*The rice weevil (Calandra oryzae)*—This is a grain pest of stored rice, and has been discussed in the chapter on wheat.



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CHAPTER IV  
SUGARCANE

*Origin and History*—While the origin of sugarcane has not yet been definitely established, there is strong evidence that the Indian and tropical canes arose independently of each other in entirely different parts of the East. Barber was of the opinion that the Indian canes probably originated in the moister parts of India (Bengal and Assam) from some plant closely related to *kans* (*Saccharum spontaneum*). He also concluded, mainly on the evidence of the Australian explorers, that the tropical class of sugarcanes probably originated in some of the larger islands of Oceania, most probably in New Guinea.

The cultivation of sugarcane in India, according to existing records, dates back to the Hindu period, although it was probably in cultivation long before that. In Sanskrit the cane is *ikshu*, *ikshura* or *ikshava* and the sugar is known as *sarkara* or *sakkara*. From India it probably spread quite early into China, Arabia and Egypt. After the Crusades it was introduced into Sicily, Portugal, the Canary Islands, and later into the New World. But even to-day the area devoted to sugarcane in India is greater than in any other country of the world.

*Distribution in India*—The distribution of sugarcane in India according to provinces is as given in the following table.

TABLE 7

Showing the distribution of Sugarcane in India

Provinces and States	Area in thousand acres in		Yield in thousand tons of raw sugar (gur) in	
	1937-38	1940-41	1937-38	1940-41
United Provinces ..	2,127	2,517	3,101	..
Bihar .. ..	342	508	356	517
Bengal .. ..	290	331	483	532
Punjab .. ..	512	549	363	470
Madras .. ..	98	162	279	485
Bombay .. ..	75	117	179	302
Hyderabad .. ..	30	50*	60	75*
C. P. and Berar .. ..	33	33	50	50
Assam .. ..	39	41	40	45
N.-W. F. Province .. ..	..	96	..	107
Orissa .. ..	34	35	63	68

From the above table it will be noticed that the United Provinces is by far the most important sugarcane-growing province in India. But whereas the Punjab comes second in acreage, in the yield of raw sugar she stands fourth amongst the provinces.

*Botanical description*—Sugarcane is a plant which belongs to the great family of grasses. But it is a tall perennial plant growing sometimes to a height of about 20 feet. It belongs to the genus *Saccharum* to which some of the most troublesome weeds of this country belong, such as *kans* (*Saccharum spontaneum*) and *sarpai* (*Saccharum arundinaceum*).

The stems of sugarcane are cylindrical, but they vary a great deal in size depending not only on the variety but also on the conditions of growth. While some varieties possess stems which are not much thicker than a lead pencil, other varieties, such as those found in the humid regions in Indo-China, may reach a maximum thickness of about three inches. The stem is jointed, that is, it possesses nodes and internodes. A stem usually possesses 30

\* approximately.

to 40 internodes but may sometimes possess as many as seventy. While most canes are thickened at the nodes, there are some that are thicker or more swollen at the internodes. Internodes possess certain characters which vary in different varieties. They possess, for instance, a groove which is a longitudinal depression extending upwards from the bud. This is present only in certain varieties, and when present it may extend over the entire length or only a portion of the internode. It may also be shallow or fairly deep. Another character which is found in these internodes is the presence of thin lines or small cracks in the epidermis which differ in nature, quantity and distribution. These lines or small cracks are known as ivory markings. Some varieties of canes also possess deeper cracks or splits in the epidermis. These also vary in number as well as in distribution. The shape of the internodes also varies with the variety. It may be straight-sided, barrelled, concave or convex.

At each node and alternately at opposite sides is a bud sometimes known as an "eye". This is an embryo shoot which makes possible the vegetative propagation of the cane. Although this structure is fairly small, yet it possesses certain characteristics which are sometimes of value in the identification of varieties. The most important of those characters are: (1) the size and shape of the bud, and (2) the flange which is the flattened edge of the bud formed by the outer bud scales. Just above the node is a ring of undeveloped roots which may develop into aerial roots, or into permanent roots when placed in the soil. The outer surface of the stem is known as the rind which may be of varying colours such as green, red, purple, white, yellow or striped. Sometimes it may even be blotched with these various colours.

The roots of sugarcane, like those of all grasses, are fibrous, stretching in all directions. The depth to which they may penetrate depends mostly on the character of the soil and the amount of water in it. Although sugarcane is not considered to be deep-rooted, yet its roots

sometimes reach a depth of 8 to 10 feet. During the sprouting of the sugarcane setts the roots begin to develop from the dormant root "eyes." These roots are known as "sett" roots and are temporary. After the emergence of the shoot from the bud, other roots are produced from the base of the shoot and are therefore known as "shoot" roots. These are the permanent roots, the "sett" roots usually dying in the early development of the plant. However, "sett" roots are essential for the development of the bud into the shoot. The extent of the root system depends on the development of other shoots from the main stalk.

The leaves of sugarcane, like those of grasses are made up of two main parts : the leaf blade (lamina) and the leaf sheath. The leaf sheath develops from the node and completely clasps the stem. The sheath may be colourless or pale-green and reaches a length of about 12 inches when fully developed. The sheath possesses certain characters which may be used in the identification of different varieties of sugarcane. These are: (1) the spines or hairs on the back of the sheath which are present in some varieties and absent in others, (2) the ligular processes which are lateral extensions of the sheath generally pointing upwards and developed at the junction of the sheath and the lamina, and (3) the ligule. The lamina may be two to three inches wide and three to four feet long. The leaves are usually green in colour, but the intensity of the colour depends on the variety. The midrib is usually whitish but may be reddish or purplish in some varieties.

The inflorescence of sugarcane is a panicle one foot or more in length with numerous branches borne at the end of the stem. It is long and tapering and is usually called the "arrow". The arrangement of the spikelets is racemose, that is, the oldest flowers are at the bottom and the youngest at the top. The spikelets occur in pairs one of which is pedicellate or stalked and the other sessile. At the base of each spikelet there is a tuft of long silky hairs, a character which has been used by some workers

for the identification of varieties. Many seeds are infertile but when the fertile ones develop they are usually small and of low vitality. This is probably due to the fact that the cane has been so long propagated vegetatively by cuttings that it has nearly lost its fertility. Sugarcane usually flowers at 10 to 12 months of age, but some varieties do not flower, especially in Northern India.

Arrowing or the appearance of the inflorescence on sugarcane is popularly believed to have a detrimental effect upon the quality of cane. Batham and Nigam working at Cawnpore (U. P.) report: (1) that there is no evidence that arrowing reduces the tonnage of juice but that, on the other hand, it tends to increase it, (2) that arrowed canes have a higher sucrose content than non-arrowed ones at the time of the flowering of the former, and (3) that the glucose content of the arrowed canes is less than in the non-arrowed ones. Rao working in Coimbatore (Madras Presidency) has shown that arrowed canes deteriorate in quality after about  $2\frac{1}{2}$  months from the time of flowering, while there is a gradual increase in the sucrose content of the non-arrowed canes. Therefore, contrary to the general opinion, held by most farmers, flowering or the arrowing of the canes does not have a detrimental effect on the amount of sucrose contained in the plant. On the other hand, evidence seems to show that arrowed canes are earlier than non-arrowed ones.

*Ecological factors*—Sugarcane will usually grow best on heavy soils, but will also do well on lighter soils where there is plenty of moisture and organic matter. In this country, the major portion of the crop, however, is grown in the Indo-Gangetic alluvium where the soils usually vary from loams to clays.

As sugarcane is a native of the tropics, its successful growth is in those regions where the climate is more or less tropical. That is, it will do best in regions which possess a warm climate. Under conditions in this country it has been found that cane growth starts when the mean temperature is about 68° F., the growth being more rapid

as the temperature increases. The growth, however, stops at about 88° F. and its optimum growth is at about 78° F. The growth of the cane stops at about 65° F, and the bud is injured at about 52° F. Investigations in this country seem to show that those regions with an average mean temperature during the growing season of about 78° F, are best suited for the growth of sugarcane. The regions should also possess a fairly high humidity but with intervals of hot dry weather. Sugarcane also requires a long growing season. In most places in India its growing period is from ten to twelve months. A certain number of heat units is required to bring the plant to maturity. In colder regions therefore it will take a longer period to reach maturity as the number of effective heat units necessary for the plant to ripen is more or less similar in the two regions. The amount of rainfall necessary for the optimum growth of the crop depends on the soil conditions as well as on the temperature. Where sugarcane grows under natural conditions, that is, without artificial irrigation, a deficiency of rainfall produces a fibrous cane; whereas under too heavy a rainfall the result is a cane of low sugar content. In this country sugarcane may be grown successfully in regions where the annual rainfall exceeds 55 inches.

*Classification*—According to Jeswiet who has done extensive work with sugarcanes in Java, the cultivated sugarcanes with its probable ancestor are divided into groups as follows, grouped according to the distribution of hairs in the inflorescence:—

- A. Main axis of the inflorescence carrying long hairs.
- B. Lodicules ciliate.....*Saccharum spontaneum* (Kans)

This is a wild form.

BB. Lodicules non-ciliate.

- C. Leaves broad.....*S. Sinense*
  - { *Pansabi*
  - { *Nargori*.
  - { *Mungo* (Uba).





is represented by *Katha* canes in the Punjab, *Chin* and *Saretha* in the Western United Provinces, *Kabri* in Bengal and *Hullu Kabbu* on the western coast of the peninsula and *Ganda Cheni* in Mysore. Those occurring in Northern India are usually thinner-stemmed. The group has been divided into two sections : (1) those possessing reddish brown stems at maturity, and (2) those with green stems at maturity. The *Katha*, *Chin* and *Saretha* canes fall in the first section, while the *Kabri*, *Hullu Kabbu* and *Ganda Cheni* are in the second. The green ones are very similar to those in the *Sunnabile* group. The canes of the reddish brown section usually grow more rapidly than those in the other section.

The canes of this group may be distinguished from those in the others by the irregular and more or less prostrate habit of growth. The canes of this group grow in different directions and sometimes may even lie flat on the ground. The stems of these canes possess long internodes which are more or less zigzag, but of uniform thickness. The leaves are often sharply bent near the tips. The group as a whole is early maturing.

The *Sunnabile* group is very widely distributed, as representatives of this group grow in most parts of the country extending from the Punjab to Assam and also in Madras. The group is represented by *Dhau* in the Punjab, *Mojora* in Assam, *Dhor* in the Central Provinces, *Sunnabile* in Bombay and *Naanal* in Madras. The stems are usually straight and regular without prominent nodes, soft, and often white in colour. The branches are few and the clumps are close and upright.

The Noble canes are thick canes commonly known as *paunda* in Northern India. They are commonly grown for chewing purposes. They require intensive cultivation and are more susceptible to mosaic. They contain a higher percentage of sucrose than the *desi* (local) varieties.

The improvement of sugarcane in this country practically began in 1912 when the central sugarcane-breeding

station was started at Coimbatore, on the recommendation of the Board of Agriculture in 1911. The station was started to produce improved canes for every part of the country. One of the reasons for the selection of a place in South India is that most of the sugarcane produce flowers and viable seeds under the conditions existing there. And as most of the sugarcane area in this country is in North India, so most of the work done at Coimbatore was to produce varieties suitable for conditions in Northern India. In the course of a quarter of a century, this station has done very valuable work and has successfully introduced certain varieties which are rapidly becoming popular in Northern India.

As a result of investigation of the Coimbatore varieties in the farms in the **United Provinces** during the last few years, the following are some of the canes now recommended by the Agricultural Department to the cultivators in different parts of the province.

*Co. 213*—This has been the standard cane of the province for several years, especially in the eastern, north-eastern and the central areas, but its performance during the last few years has not been as good as some of the newer Coimbatore varieties. However, in the Rohilkhand and Kamaun circle, experiments on the Nawabganj farm seem to indicate that this cane is still as good as the others.

The cane was probably a cross between P. O. J. 213 (female parent) and *Kansar* (male parent). This is a cane of medium thickness and is erect in habit although more or less depressed at the early stages of its growth. It is a soft cane but not too soft, and is not likely to lodge. It is very susceptible to red rot but tolerant of mosaic. The colour of the stem is somewhat yellowish and with a green tinge on the upper portions of the internodes. The growth ring is yellowish to brownish. The shape of the internode is barrelled with a slight bulge on the side opposite to the bud. The groove may be present, but if present, is not prominent. Ivory markings may occur but splits are altogether absent. The bud is of medium size, more

or less round in shape and plump. The flange is often prominent, rising at about the middle of the bud and is of almost uniform width throughout. The cane contains about 63 per cent juice, whereas the sucrose in the juice is generally 15 per cent.

*Co. 290*—This cane is a cross between *Co. 221* (female) and *D. 74* (male). This has been for some years a standard cane in the Meerut and Rohilkhand divisions. The cane is soft and is therefore easily crushed. This character of the cane, however, makes it more susceptible to attacks by wild animals. It is a weak cane and therefore lodges easily. The juice to cane ratio is 66.5 and the sucrose content in the juice is about 15.7 per cent. This cane, however, is now beginning to lose its popularity.

*Co. 312*—This is a cross between *Co. 213* (female) and *Co. 244* (male.) This cane, in many of the experiments in the United Provinces, has proved itself to be superior to almost all the other Coimbatore varieties introduced in the province. It is expected therefore that this cane will gradually spread in many districts where it has been found to do well. This is a soft cane, which tillers well and can stand unfavourable weather better than other varieties. The internodes are of medium thickness, and usually 3 to 4 inches in length. The leaves are abundant and of medium width. The cane ripens fairly early.

While this cane possesses good agricultural characters, it has been found to be susceptible to lodging on rich lands. Its sucrose content varies from 13.26 to 16.59 per cent.

*Co. 313*.—This is also a cross between *Co. 213* (female) and *Co. 244* (male). It is a medium cane with a soft, green rind. The internodes are rather long, usually about 5.7 inches in length. The cane can stand hot weather well. In habit it is semi-erect, but open at the early stages. It does not lodge easily, and possesses numerous tillers. It grows well under humid conditions. The cane, however, is susceptible to mosaic. Its sucrose content is high, reaching about 19.5 in February in Bihar.

*Co. 331*.—This cane is a cross between *Co. 213* (female)

and Co. 214 (male). It is a tall-growing variety with medium thickness and with a medium hard rind. The internodes are quite long, being usually about 6 to 8 inches in length. It can stand hot weather successfully and does not suffer seriously during periods of drought. It is erect in habit and rapid in growth. It also tillers well, and does not usually lodge. The leaves are long, erect and tough. Its sucrose content is also high, reaching about 17 to 18 per cent.

Co. 356—This is one of the sorghum-sugarcane (*jowar-sugarcane*) crosses recently produced at Coimbatore. The other members of the series are 351, 352, 353, 354, 355, and 357. Of these, 356 seems to be the most promising. This variety seems to do best in the North-Eastern Circle of the Province. The variety is early-maturing since it is a cross with *jowar*; and is also expected to require less water and also to stand unfavourable conditions better than other sugarcane varieties. The sucrose content of this cane is 16.11 (Pusa analysis).

Besides the varieties mentioned above, other Coimbatore varieties such as Co. 301, Co. 300, Co. 370, Co. 349, Cos. 51, Cos. 19, Cos. 23 and Co. 393, have been tried, and so far, results with regard to these varieties have not been very conclusive.

In the Punjab area the Coimbatore varieties have of late become very popular, so that they now occupy an area of about 44 per cent of the total area under sugarcane. The following Coimbatore varieties have more or less established themselves since they have been introduced into the province: Co. 205, Co. 213, Co. 223, Co. 300 and Co. 312.

Co. 205—This is a cross between a sugarcane known as *Vellai* (female) and *Saccharum spontaneum* or *Kans* grass (male). This is a thin cane which generally stands erect but will be crawling or slightly curved under marshy conditions. The cane is very hardy and therefore can stand unfavourable conditions fairly well. Its juice content, however, is low. In heavy soil the cane tillers well.

Its growth during the rains is very rapid. The cane splits badly, almost at every internode. The colour of the stem is glaucous green with a tinge of yellow at the base of the internodes. The internodes are straight-sided. The bud is small to medium, generally obovate and flat. The flange in the bud is not conspicuous.

*Co. 223*—This is probably a cross between *Chittan* (female) and *Naanal* (male). It is a medium cane with an erect habit. The colour of the cane is a light pinkish purple appearing ashy on account of the overlying waxy layer. The root zone is whitish but the growth ring is yellow. The stems are thinner in the upper portion of the internodes, with a moderate amount of ivory markings, and the splits are few.

*Co. 300*—This cane is a cross between *Co. 213* (female) and *P. O. J. 1410* (male.) It is a medium thick cane, straight-sided with medium hard rind. The internodes are about 4 inches in length and splitting is absent. The lower nodes sometimes develop aerial roots under humid conditions. The cane suffers under continuous drought. The cane also does not lodge easily. The sucrose percentage of the cane is about 17 per cent.

Besides these five Coimbatore varieties, the province also grows to some extent certain local varieties such as *Lalri*, a thin cane, *Katha*, an indigenous cane of the Punjab, *Suretha* which is a thicker, softer and whiter cane than *Lalri*, *Dhaultu*, a white soft chewing cane and *Bodichin*, the latter two being usually grown under *barani* conditions.

**In Bihar and Orissa** the most promising of the Coimbatore varieties seem to be *Co. 331*, *Co. 318*, *Co. 313*, *Co. 312*, *Co. 301* and *Co. 299*.

*Co. 331*—This is a very promising cane in the conditions where it has been tried in Bihar, and has therefore been highly recommended to the cultivators. It is also one of the canes recommended in the United Provinces and has therefore been mentioned with the U. P. canes.

*Co. 318*—This cane has resulted from the selfing of *Co. 229*. It is a medium thick cane with a very hard rind.

In habit it is straight and erect, and stands thick and uniform in most types of soil. It tillers freely. Its leaves are abundant. It is claimed to be flood resistant, and is likely to tolerate *usar* conditions to some extent. The cane does not lodge even with strong winds, and may even be used as a wind-break for other varieties of cane. It ripens late in Bihar.

Co. 313—This is an early cane in Bihar and is preferred by the mills on account of its high sugar content and is liked by the cultivators because of its high yield. This cane is also one of those recommended for certain areas in the United Provinces and was therefore discussed in that section.

Co. 312—This cane has been recommended for regions in South Bihar, as its yield in that area is fairly high. This is one of the most highly recommended canes for the United Provinces, and has therefore been discussed.

Co. 301—This is a cross between Co. 213 (female) and P. O. J. 1399 (male). It is a medium thick cane with a medium hard rind, and ripens between the early mill varieties and the mid-season ones. In habit it is semi-erect to erect at maturity, but susceptible to lodging. It stands drought well but tillers badly in light soils. It grows well in the humid weather but is susceptible to top-rot. This variety is also considered to be highly resistant to floods.

Co. 299—This is a cross between Co. 213 (female) and P. O. J. 1410 (male). It is early, ripening in about November, and has therefore been distributed as an early mill cane in North Bihar. In habit, the cane is generally erect but slightly curved towards the top. It has slow and bushy growth but grows rapidly during the rains. It stands the hot weather fairly well. The cane, however, does not tiller well and is susceptible to lodging.

#### CULTURAL METHODS

There are three different methods of planting sugarcane commonly used.

1. Planting on the level or on the flat.
2. The "ridge and furrow" method.
3. The trench method of planting, sometimes known as the Java method.

1. In the first method the land is simply ploughed, rolled and levelled. The cane setts are then planted on the level and covered with soil to a depth of about two inches only. The setts are placed end to end in rows which are about  $2\frac{1}{2}$  to 3 feet apart. This practice is generally followed when there is abundant moisture in the soil.

2. The ridge and furrow method consists of planting cane setts in furrows which are  $2\frac{1}{2}$  to 3 feet apart, depending on the variety of cane, the former distance being usual for the thin canes and the latter for the medium thick ones. The depth of the furrow depends upon the kind of soil and season of planting. The furrows are usually opened with a double mould-board plough.

The cane setts may be placed end to end in a furrow, but when cane with long internodes is planted, such as the Coimbatore canes, it is preferable to plant the setts eye to eye. This will decrease "gappiness" or the number of gaps in the rows. In order to ensure a good stand at the end of the furrows it is also advisable to plant double setts for about two yards. The doubling of the setts at the ends is necessary on account of the unfavourable effects on borders. After the setts have been placed in the furrow a gatherer and roller is drawn over the furrows in order to fill them up and to cover and press the setts.

3. For trench cultivation, the land is ploughed immediately after the *rabi* crop is harvested, and then left fallow during the hot weather. The land is ploughed as many times as practicable during the rains. The trenches are then made during the month of October or November, but the operation should be finished by the end of November, as the soil has to be exposed to the weather in order to give the best results. The trenches made for thick



and medium canes are two feet wide and 4 feet from centre to centre. The trenches are dug 6 inches deep and the soil is placed on the two-foot space left between trenches. After the trenches are made, the soil in the trenches is stirred up to a depth of about 9 inches and the soil is thoroughly mixed with the manures or fertilizers that are to be applied in the trenches. The trenches are then ready for planting.

The setts may then be placed in the middle of the trenches and are pressed down in the soft soil and finally covered with soil to a depth of about 3 to 4 inches. If there has been no rain previous to planting, the trench should be irrigated about two or three weeks before planting and the soil should then be stirred with *pharwas* (hoes) just before planting.

As sugarcane setts are usually attacked by white ants, it is advisable to treat the setts before sowing. This is done by dipping the setts in a mixture of water and coal tar at the rate of 10 drops of coal tar to a gallon of water. This mixture should then be boiled before using. When the mixture is cool the setts are immersed in the mixture and planted immediately. In adopting this method one should see that no tar remains free in the mixture as it may injure the "eyes" or buds.

In places where sugarcane smut is common, it is sometimes desirable to immerse the setts in Bordeaux mixture in order to prevent the occurrence of smut or some other fungous diseases. The selection of healthy canes for setts is also important where mosaic and red rot are common.

The amount of seed per acre varies with the method of planting, the variety of cane, distance between rows, etc. When the setts are planted eye to eye, more seed will be required per acre than when planted end to end. The number of setts also depends on the length of the internodes in the cane. A sett is usually a piece of sugarcane stem containing two or three buds or "eyes". Using the trench method of planting the amount of seed required per acre is

about 60 maunds of thick cane and 40 maunds of medium cane when stripped, or approximately 1,600 to 2,000 canes.

*Cultivation after sowing*—Cultivation or the constant stirring up of the soil is of primary importance with sugarcane. The first two or three hoeings are done even before the plants have appeared above the ground. During this operation, which is generally done by *pharwas*, care must be taken not to injure the shoots which may be coming up through the soil. When the canes are planted in trenches, these are gradually filled with earth when the canes have attained a height of about 2 to 3 feet above the ground. After the trenches have been filled in and before the rains begin, it is necessary to earth up the canes. This is essential in order to reduce the amount of lodging in the crop. After this, very little attention is required in the way of cultivation during the monsoon.

*Irrigation*—Sugarcane is a plant that requires plenty of water. So in most parts of India, where rainfall is not sufficient to mature the sugarcane crop, artificial irrigation becomes necessary. Mollison in Bombay claims that an irrigation of about 80 inches throughout the growing period with an average rainfall of about 30 inches is just sufficient to mature a crop. Roberts and Faulkner in the Punjab also estimate that an irrigation of about 80 inches is necessary for thick canes and 50 to 60 inches for thin canes. However, the amount of irrigation water required depends on the amount of rain received, the type of soil and the variety of cane. The number of irrigations generally given may therefore vary from 7 to 12 during the whole period.

*Manuring*—Sugarcane is a crop that requires heavy manuring. The amount of nitrogen usually required for a good crop of sugarcane is from 150 to 200 lbs per acre. However, in the case of organic manures (especially animal manures), it is not desirable to apply them directly to the crop, as this may attract white ants or delay ripening. When green-manuring is practised, crops of *dhanchia* (*Sesbania aculeata*) in Bengal and Madras, sunn-hemp

(*Crotolaria juncea*) in Bihar and the United Provinces, and *senji* (*Melilotus parviflora*) in the Punjab, are generally grown in the *kharif* season previous to the planting of sugarcane. The green crop is then ploughed under some time before the preparation of the land for the sowing of sugarcane.

Other organic fertilizers commonly used in connection with sugarcane are farmyard manure usually applied at the rate of 20 to 30 cart loads (400 to 500 maunds) per acre. This manure is usually applied soon after the trenches are dug, and mixed in thoroughly with the soil in the bottom of the trench. This type of manure is applied at this time in order to allow sufficient time for its decomposition to take place; otherwise, white ants may be attracted by the undecomposed manure. Castor cake or mustard cake is usually applied at the time of planting at the rate of about 7 maunds per acre.

Some of the commercial fertilizers that may be applied profitably to sugarcane in India are ammonium sulphate and superphosphate. Chilean nitrate also has been used but does not give results as good as those of ammonium sulphate. It also seems very probable that the application of large quantities of available nitrogen tends to reduce the quality of the cane for gur-making. This type of manure is usually applied after first ridging up the young plants. The method of application of these fertilizers consists in putting in spoonfuls of the fertilizer with small wooden spoons in holes dibbled on ridges near the stools. Then the holes are covered up and pressed with the foot. The advantage in applying it in this way is the reduction in the loss of the fertilizer which may be caused by leaching.

*Tying and trashing*—Most varieties of canes which possess soft rinds frequently lodge and therefore need tying up. This practice is also beneficial as it minimizes the damage from insect and disease attacks, and makes the growth of canes uniform and clean. This may be done by tying together the canes of several clumps. The outside canes are sometimes propped by tying a stout

string or wire all round the field of sugarcane.

Another method of minimizing lodging is known as "trashing". This consists in the removal or tearing away of the older leaves as the canes grow. While this practice has been found to be advantageous in places where high winds commonly occur, in other places it has been found to be disadvantageous as the scars formed by trashing afford good resting places for the development of the spores of fungi.

*Harvesting*—When the canes are mature, which condition is generally recognized by the withering of the top leaves, the crop is fit for harvesting. Ripeness may be further confirmed by testing the sweetness of the canes.

Harvesting is usually done by cutting with sickles as close to the ground as possible. The canes are then stripped and topped and then tied in bundles, ready for transportation.

*Ratooning*—When the root-stocks from which the canes have been removed are left in the soil, a new growth of canes is produced. The canes produced in this way are known as "ratoons", and the crop grown in this way for the first time is known as the "first ratoon"; and if this process is repeated for the second year, the crop will be known as the "second ratoon"; and so on. Sometimes this process is continued for several years, but in India this practice is not common. The introduction of Coimbatore canes, however, has made this practice more popular in certain cane areas in the Punjab. While this method does away with the operation of planting cane for as long as it is continued, it has been found that the continuous growing of the crop by ratoons steadily diminishes the yield, so that it makes the practice usually unprofitable. In general, for most soils, it is not advisable to grow more than the second ratoon. The practice has one more serious disadvantage in that the crop is on the land continuously, allowing favourable opportunities for the development throughout the year of the numerous insect pests and diseases which prey on the crop. Ratooning is inad-

visible in this country where red rot of sugarcane is common.

### DISEASES

Sugarcane has a very large number of enemies in the form of fungi, insects and even animals. Some of the most common diseases and pests which attack the sugarcane crop in this country will be dealt with here.

*Red rot*—(*Colletotrichum falcatum*, Went)—This is probably the most common disease not only in India but in other cane-growing countries as well. In India it is found almost everywhere where sugarcane is being grown.

The disease usually shows no sign of its occurrence until the canes are seriously affected. The first external sign of this disease is that the upper third or fourth of the leaves of the shoot begin to show signs of yellowing and withering. The edges of the leaves thus wither, leaving the centre green. Finally the whole top withers and droops as if affected by drought. On splitting the stems open, it will be found that the tissues inside are irregularly coloured red in streaks, these streaks or bands usually extending out from the region of the nodes. The characteristic of this disease is the appearance of white blotches surrounded by the red tissue. In the white spots a mould is always present, a few threads of mycelium being found in the red patches.

The reddened tissues which are caused by this disease are more commonly found near the base of the stems. The reddening in the later stages may change to brown or light brown colour. The disease is usually accompanied by a sour smell which may be detected when the diseased canes are split open during the early stage of the attack.

The damage by this disease to sugarcane in India is very great, and therefore control measures should be adopted to prevent it. The preventive measure against this disease is the planting of healthy stock. In areas where this disease is common it would be well to bring

healthy seed canes from outside. It has also been found that the thin canes of India are less susceptible to red rot than the thick ones.

The introduction of canes that are less liable to the attack of this disease will, to a large extent, successfully control the prevalence of this disease.

*Mosaic*—Sugarcane mosaic is probably caused by an ultramicroscopic particle known as a virus. This is much too small to be seen even with the highest-powered microscope. It is estimated to be some forty times smaller than a bacterium whose size is about twenty-five thousandth of an inch in length. Research workers are not yet agreed as to whether a virus is living or non-living or even intermediate between these two states of matter.

Sugarcane attacked by this disease shows a mottled appearance in the leaves, that is, light-coloured patches alternate with green. These light-coloured patches are elongated and run parallel to the axis of the leaf. The mosaic patterns on different varieties of sugarcane differ considerably. These mosaic areas cover practically the whole of the leaf blade in severely diseased plants. The disease, however, is not so easily distinguished in the thin canes.

The agent causing the disease is believed to be carried from plant to plant by insects. Such insects as *aphids*, *jassids*, and grasshoppers are definitely known to spread virus diseases. Although the plants attacked by this disease are not killed, yet it has been found that there is a reduction in the yield as well as in the sucrose content of the canes.

The disease in India may be controlled to some extent by growing mosaic resistant varieties. Luthra and Sattar, working in the Punjab, report that certain varieties such as *Labri*, *Kabu* and *Kansar* as well as a number of the Coimbatore varieties such Co. 314 did not show any incidence of mosaic. The following varieties, however, varied in their infection by mosaic, from 5 to 20 per cent. Co. 313.

Co. 300, Co. 213. Among those which showed more than 20 per cent infection was Co. 205. In general it appears that the thin canes are less susceptible to the attack of mosaic than the thicker varieties.

When the disease has appeared in the field the affected plants should be removed and burnt.

*Smut (Ustilago sacchari, Rabenh)*—This disease is found in all parts of India. The disease can be easily recognized by the black whip-like projection which appears on the top of the shoot, and is several feet in length. This shoot is leafless. The disease is more prevalent among the thinner varieties of cane such as *Saretha*, *Sunn-bile* and *Katha*. The manner in which the disease spreads is not definitely known. It is believed that it may be transmitted through setts from infected canes. The disease, however, is not known to do very serious damage.

The best methods of controlling this disease seems to be the removal and destruction of the affected plants by burning, and by growing only those varieties which are known to be resistant to the disease.

*Brown leaf spot (Cercospora longipes, Butl.)*—This is a very common sugarcane leaf disease in this country, but it is confined largely to the thin canes. The disease is known by the narrow oval spots about 1/8 inch long and of a reddish colour. Upon full development the red spots develop brown centres. The spots may be seen on both surfaces of the leaf. When the attack is serious it imparts a reddish tinge to the foliage. While the disease does not kill the plants, nevertheless it injures the leaf surface and thereby reduces the yield of sugar. At present, no practical method of treating this disease is known.

*Other diseases* which sometimes are found to damage sugarcane plants are sugarcane wilt (*Cephalosporium sacchari*, Butl.), collar rot (*Hendersonina sacchari*, Butl.), eye spot (*Helminthosporium sacchari*, Butl.), sooty mould (*Capnodium* sp.), ring spot (*Leptosphaeria sacchari*, van Breda) and rust (*Puccinia Kuehnii*, (Kr.) Butl.).

## INSECT PESTS

The Sugarcane stem borers (*Argyria sticticraspis*, *Chilo zonellus* and *Diatrea venosata*)—All these three insects are very much alike in all their stages of development. The nature of their damage to sugarcane is also the same. All the three insects are moths in the adult stage. But they do most of their damage to sugarcane in their larval stage, when they are known as caterpillars. The eggs are usually deposited on the lower surface of the leaves in clusters of about twenty. These eggs hatch into caterpillars which are pinkish in colour with black heads and short dark spines. These caterpillars in their early stages feed on the leaves and later bore into the stems which they hollow out, thus interfering with the circulation of sap, and causing what are generally known as "dead hearts". A complete cycle of these insects takes about 6 weeks during the hot weather.

The borers may be controlled to some extent by the following measures:

1. As the insects are attracted to light they may be collected in light-traps placed on dark nights in and near the affected fields.
2. Only unaffected setts should be planted.
3. Ratooning should be avoided in places where these pests are common.
4. As these pests also attack maize, and *jowar* it is advisable to pull out all affected plants of maize, *jowar*, and sugarcane early in the season and destroy them.

The sugarcane hispa (*Asmangulia cuspidata*)—This is rather a small insect about one-eighth of an inch in length, black in colour, with characteristic black spines on the body. Most damage to sugarcane by this insect is done by the larva of this beetle known as the grub. The grub tunnels into the leaves which turn brown or light-coloured. The grub, when full-grown, pupates in the tunnel and emerges as a beetle. In North India three to four generations are produced in the course of a year, but they are most



common during the monsoon.

The pests may be controlled to some extent by catching them with hand-nets. Affected leaves also should be removed and burnt.

*The sugarcane leaf-hoppers* (*Pyrilla nysana*, *P. aberrans* and *P. perpusilla*)—These three species of insects are very similar in appearance and habit. The adults are small active insects about one-third of an inch in length. The adults as well as the nymphs jump about quickly from place to place if disturbed. The young ones are pale brown in colour and the adults possess brownish wings. The young ones take about two months before they reach the adult stage. The damage to sugarcane by these insects is done both by the young and the adults by sucking the juice from the leaves.

The pest may be controlled by collecting the eggs which will usually be found in a mass covered with filamentous white material and which shows up conspicuously against the green background of the leaf. This mass of eggs is found on the lower surface of the sugarcane leaf. Or the leaves containing the eggs may be removed and destroyed. The pest may also be controlled by bagging the adults with hand-nets and destroying them.

*The white ants or termites*—Termites, commonly but incorrectly called "white ants", are responsible for a great amount of the damage done to the sugarcane crop in this country. In their attack on sugarcane they usually begin at the roots and work towards the main stem, until the plant withers and dies. The damage is usually worse in loams than in stiff clays.

One of the methods used in the control of white ants is the use of irrigation water charged with crude oil emulsion at the rate of 5 seers per acre. The best way to apply it, is to place the emulsion in a gunny bag and place it in such a way that the under-surface of the bag just touches the water in the irrigation channel. This method does not destroy the white ants but drives them away; hence it may be necessary to repeat this process two or three

times during the season.

Some of the *minor pests* of sugarcane are the mealy bugs (*Pseudococcus saccharifolii*, Gr. and *Trionymus sacchari* (Ckll.), the cane white-fly (*Aleurolobus barodensis*, Mskll.), the top shoot-borer (*Scirpophaga nivella*, Fabr.), and the root-borer (*Emmalocera depressella*, Swinh.)

Sugarcane is also sometimes subject to the attack of a flowering plant which is partially parasitic on the roots and is known scientifically as *Striga lutea*. The parasite sends out its roots which branch very extensively forming a network of fine rootlets which entwine the roots of the canes. The canes thus attacked remain stunted and appear as if they were affected by drought. The plant itself possesses leaves, by which it can manufacture part of its food, and is therefore not altogether dependent on the host on which it is parasitic. The plant also possesses several branches on which it bears flowers and produces seeds.

The only method of controlling it is probably by preventing it from going to seed. Where the land is badly infected with this weed, sugarcane as well as *jowar* should not be grown for some years, as these two crops are known to be host plants to this parasite.

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## CHAPTER V

# COTTON

*Origin and history*—Cotton has been used in this country as a fabric from time immemorial. The first reference on record to the use of cotton in this country was that found in the Rig Veda. Cotton was also mentioned in the Laws of Manu. The use of cotton therefore for weaving, must have been known for generations before these records.

Recent work on cotton has shown that there are at least three different groups of cottons, based largely on the chromosomal and genetical behaviour, with different centres of origin. The first group consists of the wild and cultivated cottons of the Old World with 13 chromosomes. These are the species *arboreum* and *herbaceum* of the Old World. The latter is believed to have originated in Africa, whereas *arboreum* developed in the continents of Africa and Asia. The second group includes the wild cottons of the New World also with 13 chromosomes. These are indigenous to the western coasts of the United States of America and Mexico. The third group is made up of the cultivated American cottons and three wild species from islands in the Pacific, with 26 chromosomes.

*Distribution in India*—While cotton is grown in almost all parts of India, it is mostly grown in the black cotton soil area of the country, and also to a considerable extent in the upper parts of the Indo-Gangetic alluvium and Sind. The following table shows the distribution of cotton in India according to provinces and states.

TABLE 8

Showing the distribution of Cotton in India

Provinces and States	Area in thousand acres in		Yield in thousand bales (400 lb.) in	
	1937-38	1940-41	1937-38	1940-41
Punjab .. ..	3,135	2,669	1,140	1,215
C. P. and Berar .. ..	4,047	3,585	711	901
Bombay .. ..	3,862	3,885	734	781
Bombay States .. ..	2,312	2,230*	479	600*
Hyderabad .. ..	3,563	3,700*	579	580*
Madras .. ..	2,569	2,412	504	530
United Provinces .. ..	567	394	193	146
Sind .. ..	970	931	354	330
Punjab States .. ..	851	540*	373	180*
Central India States .. ..	1,337	1,160*	143	160*
Baroda .. ..	914	750*	136	100*
Rajputana States .. ..	524	500*	63	70*
Gwalior .. ..	668	620*	78	60*
Bengal .. ..	58	81	28	29
Others .. ..	700*	730*	160*	170*

*Botanical description*—The cotton plant belongs to the *Malvaceae*, or mallow family, to which other economic plants such as *bhindi* (*Hibiscus esculentus*), roselle or *patwa* (*H. sabdariffa*), and *patsann* (*H. cannabinus*), belong. The genus *Gossypium* to which cotton belongs contains several species which are both wild and cultivated. The number of indigenous cultivated species in India, according to a recent classification, is only two, namely, *G. herbaceum* and *G. arboreum*, which are sub-divided into several “forms” or varieties.

The cotton plant is shrubby, herbaceous or tree-like, and in the wild state under tropical conditions it is perennial, but most of the cultivated cottons in the world to-day have developed into annuals. Under cultivation the plant is a much-branched, more or less herbaceous shrub, growing to a height of from two to six feet.

\* approximately.

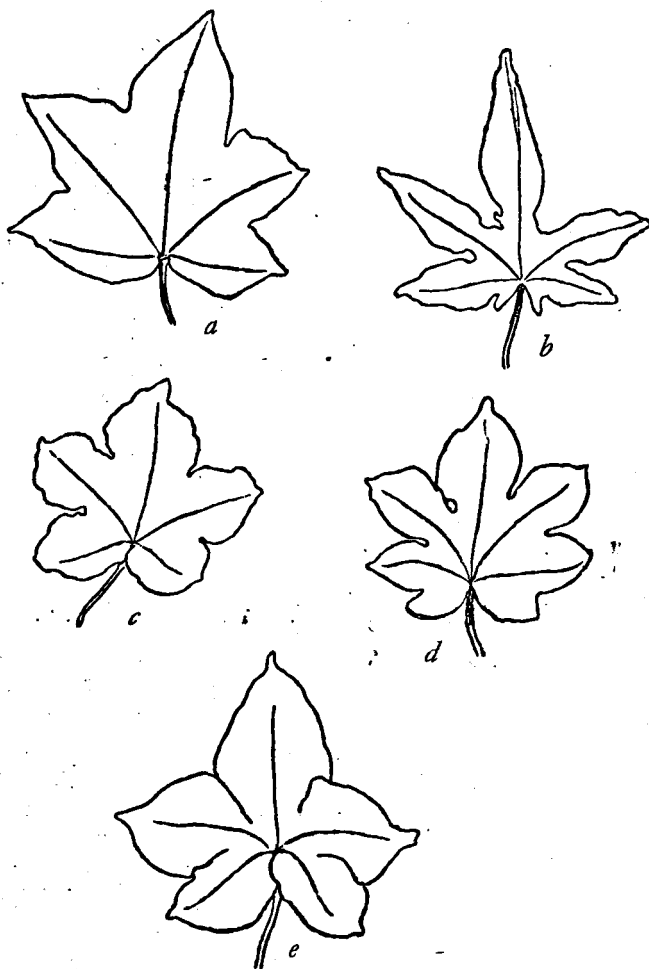


Fig. 4. Cotton leaf outlines.

(a) *G. hirsutum*. (b) *G. arboreum*. (c) and (d) *G. herbaceum*.  
(e) *G. barbadens*.

(After Hutchinson and Ghose. Drawn by R. C. Sutradhar)

The main *stems* are erect and branching. The branches develop from buds located at the nodes of the main stems. The branches are of two types: (1) the *vegetative* (monopodial) branches and (2) the *fruiting* (sympodial) branches. Vegetative or monopodial branches arise from buds at the base of each leaf. These buds are of two kinds: (1) the axillary and (2) extra-axillary buds. The vegetative branches usually develop from the axillary buds, but may also develop from the extra-axillary ones. The fruiting branches develop only from the extra-axillary buds. Sometimes both axillary and extra-axillary buds may develop in the same leaf axil, and therefore both types of branches may arise from the same node. Only fruiting branches bear flowers, whereas vegetative branches do not bear them, but these may give rise to fruiting branches. In most cultivated cottons, fruiting branches do not develop on the lower part of the main stem. It is the vegetative branches which determine the general form of the cotton plant. When there is a considerable development of the lower vegetative branches, the plant acquires a bushy appearance.

The *leaves* of cotton are very variable in shape as well as in size. The leaves are lobed, but the number of lobes in a leaf also varies from three to nine. The lobes may be broad, narrow or laciniate. The leaves are arranged about the stem in regular spirals. On the main stem and vegetative branches, the arrangement of the leaves, or phyllotaxy, of the Old World cottons, is generally  $1/3$ . That is, there are three leaves from one leaf to the next directly above it. The American cottons usually have a  $3/8$  arrangement. The fruiting branches do not possess this spiral arrangement of leaves. The leaves sometimes possess certain structures which are known as glands or nectaries which secrete certain substances from the plant. These, when they occur, are usually found on the lower surface of the leaf. The presence or absence of these is sometimes a help in the identification of certain strains of cotton.



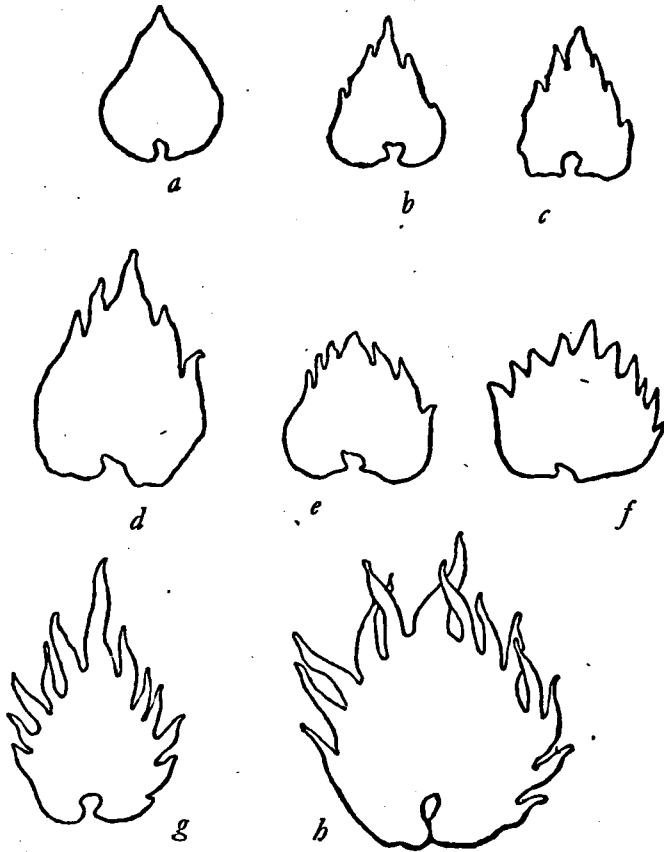


Figure 5. Outlines of bracteoles of cotton.

(a), (b), (c) and (d) *G. arboreum*. (e) and (f) *G. herbaceum*.  
(g) *G. hirsutum*. (h) *G. barbadense*.

(After Hutchinson and Ghose, drawn by R. C. Sutradhar.)

The *inflorescence* of cotton consists of solitary and axillary flowers. The flowers are typical of the *Malvaceae* family. The flowers of *Gossypium* are, however, different from those of the other genera of the family (except *Hibiscus*) in that the anthers in the staminal column are borne below the summit, whereas in the other genera these are borne at the summit. The flowers of the genus *Gossypium* differ from those of *Hibiscus* in that they possess only three bractlets of the involucre whereas the flowers in the latter possess more than three.

The flower is developed at a node opposite to a leaf in fruiting branches only. It consists of the following parts:—(1) The pistil which is formed from several carpels, the number of which may be known from the number of lobes on the summit of the stigma, the carpels later on developing into 'locks' in the boll, (2) The stamens which are very large in number, and are arranged in a tubular form known as the "staminal column" which envelops the style of the pistil, (3) Five petals which are united at the base, forming together what is known as the corolla. While the colour of the corolla, in most cultivated cottons, is yellow with a red spot at the bottom of each petal, there are numerous variations depending very largely on the variety, (4) Five green sepals joined together forming a cup-like calyx. At the base of the calyx on the inner side, floral nectaries usually occur, (5) The involucre which is usually made up of three or four bracts united at the base. These bracts may be large, entire, dentate, or laciniate. At the base of the outer surface of the bracts, nectaries occur in American cottons but are absent in the cultivated Asiatic cottons.

Normally, cotton is self-fertilized, but natural crossing occurs. When two varieties of cotton are planted side by side in two adjacent rows, natural crossing may take place in from 4 to 20 per cent of the cases but as the distance between two varieties increases, the amount of natural crossing diminishes very rapidly. The fruits of cotton, in which are enclosed the seeds and the fibres, are

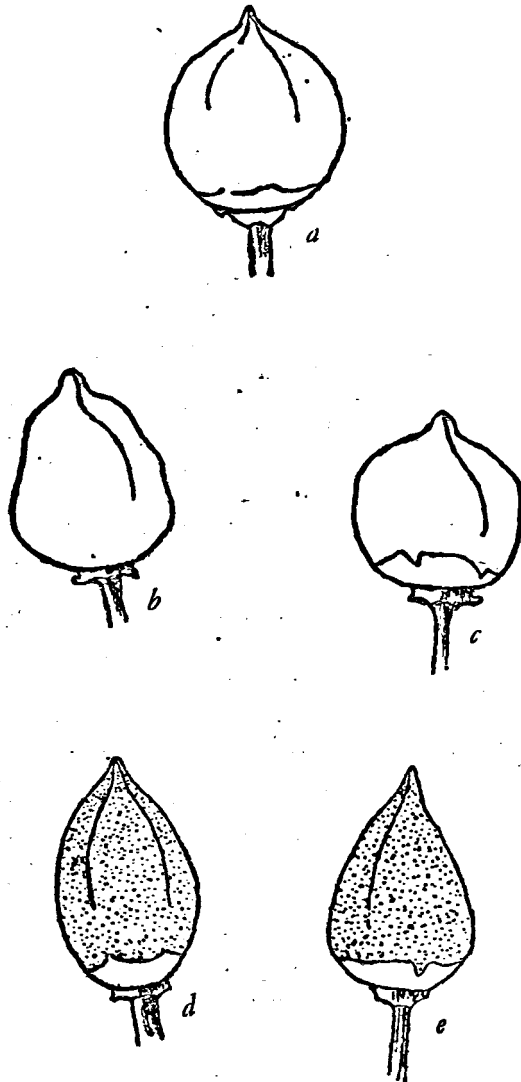


Figure 6. Cotton bolls.

(a) *G. hirsutum*. (b) and (c) *G. herbaceum*. (d) *G. barbadense* (e) *G. arboreum*.

(After Hutchinson and Ghose, Drawn by R. C. Sutradhar)

called "bolls". These also vary in size as well as in shape, but are usually more or less egg-shaped, only smaller and more pointed at the end. Bolls are made up of divisions or locules which are commonly known as "locks". In most cottons, when the boll ripens, the locules open by separating along their central axis and splitting at the same time along the lines of divisions known as sutures. The number of bolls on a cotton plant varies with the variety, cultural methods and climatic conditions.

The number of seeds in a lock is about nine, so that each boll may contain from twenty-four to fifty seeds.

The cotton fibre is simply an elongation or outgrowth of an epidermal cell of the seed coat. This outgrowth may continue until it reaches a length of an inch or more. These long outgrowths form the "staple" or "lint" which is the cotton fibre of commerce. The shorter outgrowths form what is known as the "fuzz" and is of little commercial importance. Some varieties produce seeds which contain no fuzz and when ginned are practically free from fibres, and are therefore called "naked". The fibre is tubular, but on ripening becomes flat and ribbon-like. On collapsing it forms a spiral band by reason of the unequal collapse and contraction of the cell-wall. The number of twists in the fibre varies with different varieties. In the Indian cottons the average number of twist is about 150 per inch, whereas some of the best cottons may have as many as 300 twists per inch.

The quality of cotton fibres depends upon several characters. The following characters are important in determining quality.

1. The strength of the fibre, that is the actual strain that a fibre can withstand.
2. The number of twists and the character of the twists in the fibre. Fibres with numerous twists, everything being equal, make the strongest yarn.
3. Fineness : This character is mainly due to the thickness of the cell-wall. The Indian cottons usually

have thick walls and are therefore characterized as coarse, whereas the American cottons usually have thin walls and possess a silky "feel", and are therefore known as "fine" cottons.

4. **Uniformity of the fibres:** The fibres should be of uniform length, as lack of uniformity in the length of the fibres will result in an undue amount of waste in manufacture.
5. **The length of the fibre:** Cottons having long fibres are usually preferred to short ones. Indian cottons usually possess short staple lengths.
6. **Colour and lustre:** Good cottons should possess a rich bright creamy colour.
7. **"Counts":** This is a term used to evaluate the quality of cotton fibre. A count is the number of hanks required to weigh a pound. A hank contains 840 yards of thread. The finer the thread, therefore, the greater will be the "count". Indian cottons ordinarily spin up to about 22 "counts", whereas the best quality cottons may range from about 80 to even 400 "counts".
8. **"Neppiness":** This is caused by the failure of individual fibres to thicken, resulting in small entanglements of the fibres firmly knotted together and incapable of being unravelled. These entanglements are usually formed during the process of ginning. This is an undesirable character more common in certain varieties of cottons than in others.
9. **Ginning percentage:** This is the amount of lint obtained in relation to the amount of cotton (*kapas*) fed into the gin. A variety of cotton with higher ginning percentage is preferable, as more lint is obtained per unit weight of seed cotton (*kapas*).

Normally the *root system* of a cotton plant possesses a long tap-root from which the laterals or feeding roots

arise. The length of the tap-root may be 3 feet or more. The laterals are only a few inches below the surface of the soil and branch out in all directions. These usually arise from four grooves on the main root, forming four groups of lateral roots.

*Ecological factors*—The cotton plant is very sensitive to environmental stimuli, which accounts in part for the various types or forms of cotton under cultivation in India at present.

On the basis of ecological factors, namely, soil and climate, the indigenous cottons of India may be broadly divided into two groups:

1. Those that require eight months to mature.
2. Those which reach maturity in five months.

The first group are generally grown in those regions where the growing season is long, that is, where frost does not occur during the whole length of the long growing season required by them. The second group are mainly confined to Central and Northern India where frost generally occurs during the winter.

The cotton plant requires a rather high and uniform temperature during the early stages of its growth, as this encourages vegetative growth. During this period the crop should also have plenty of moisture in the soil whether supplied by rain or irrigation. In the later stages of its growth the temperature should be lower preferably with cool nights. These conditions serve to check vegetative growth and encourage fruiting. If during the fruiting period heavy showers of rain occur, the shedding of the flowers and young bolls may result. This also may be caused by heavy irrigation at this stage.

During the harvesting season it is necessary that the weather should be clear, as showers of rain at this time will discolour the lint and thereby reduce its quality.

In this country the cotton plant is cultivated under a wide range of soil conditions. But the major portion of the crop is grown on the Indo-Gangetic alluvium and the black cotton soils.

*Classification of cottons.*—The genus *Gossypium* has been one of the most difficult to classify, and therefore a great deal of confusion has resulted. Sir George Watt, the great authority on cotton, who was for some time a professor of botany in the Calcutta University, in his monograph published in 1907, described 42 distinct species and varieties of *Gossypium* and divided the wild and cultivated cotton plants of the world into five "sections". More recently the wild and cultivated cottons of the world have been divided into three groups. One group consists of the wild cottons of the New World, with 13 chromosomes. The second group consists of three wild species from islands in the Pacific, and the cultivated American cottons with 26 chromosomes. The last group consists of the wild and cultivated cottons of the Old World with 13 chromosomes. Among the cultivated cottons, four species according to their classification contain the most important varieties. These may be classified as follows:—

New World Cottons: (1) *G. hirsutum* and (2) *G. barbadense*.

Old World Cottons: (1) *G. arboreum* and (2) *G. peruvianum*.

General key for the identification of the most important cultivated species of cotton in India (Adapted from Hutchinson and Ghose's classification).

- A. Bracteoles gashed into a varying number of long acuminate teeth closely investing the bud, flower and boll.
- B. Habit varying from monopodial to sympodial. Leaf lobes ovate—oblong, usually overlapping at the base causing the sinuses to be thrown up in folds. Corolla not widely expanding, forming a narrow cup. Bolls long, tapering, shiny, dark green, profusely pitted, with oil glands at the base of the pits....*Gossypium barbadense*.
- BB. Habit sympodial with no or very few vegetative branches. Leaves occasionally palmatisect. Leaf lobes divergent, broadly triangular, not constricted at the

- base, not overlapping. Corolla widely expanding. Bolls rounded, often large, pale green, surface smooth, oil glands few and sunk beneath the boll surface. . . . .*G. hirsutum*.
- AA. Bracteoles rounded or broadly triangular, broader than long, with margin divided into a number of triangular teeth, flaring widely from the base of the bud, flower and boll. Bolls rounded, or with prominent shoulders, boll surface smooth, or very shallowly dented, with few or no oil glands. . . . .*G. herbaceum*.
- B. Habit sympodial, without or with very few spreading vegetative branches. Petioles, pedicels and leaves hairy or sparsely hairy. Stems almost glabrous below. Leaves large, leathery, usually flat and only slightly constricted at the base of the lobe. Bolls 1" to 1½" long, not more than 11 seeds per loculus. . . . .*Var. typicum*.
- BB. Habit sympodial or monopodial with ascending vegetative branches. Young shoots woolly. Stems, petioles, pedicels and leaves intensely hairy. Leaves large, thick, ruffled, and only slightly constricted at the base of the lobe. Bolls 1" to 1½" long, not more than 11 seeds per loculus. . . . .*Var. frutescens*.
- BBB. Habit monopodial with many ascending vegetative branches. Leaves small, thin, flat, and deeply constricted at the base of the lobe. Stems, petioles, pedicels, and leaves almost glabrous. Bolls ¾" long or less, usually 5—7 seeds per loculus. . . . .*Var. Africanum*.
- AAA. Bracteoles triangular, longer than broad, entire or with three or four coarse teeth, closely investing the bud, flower and boll, occasionally spreading away from the apex of the boll. Bolls tapering, profusely pitted, with prominent oil glands in the pits. . . . .*G. arboreum*.
- B. Habit monopodial with many vegetative branches, growing into a bushy shrub, bolls 1" to 1½" long, not more than 11 seeds per loculus. . . . .*Var. typicum*.
- BB. Habit sympodial, with few or no vegetative branches, growing into a small shrub, not bushy, 2'—6' high.
- C. Bolls 1"—1½" long, not more than 11 seeds per loculus. . . . .*Var. neglectum*.
- CC. Bolls 2" or more long, with 13—17 seeds per loculus. . . . .*Var. cernuum*.



*Gossypium barbadense*—This group of cottons which is more commonly known as the Sea Island cottons includes most of the long staple cottons of the United States of America and of Egypt. In India these cottons are more commonly known as Egyptian cottons. This group is mainly confined to Sind where it is gaining in popularity. Of this group of cottons two improved strains have been evolved which are now recommended to the cultivators by the department of agriculture in Sind. These are known as "Improved Sind Egyptian Boss III—16", which has been evolved from Zagory Melaky, a variety imported from Egypt, and "Improved Sind Sea Island Cotton 2.4", which has been evolved from a variety originally imported from America. Boss III—16 has a very long staple length of  $1\frac{1}{4}$  inches to  $1\frac{1}{2}$  inches and is very fine and silky. It spins 80's and its ginning percentage is 32 per cent. This strain has especially been recommended for East Sind. Sea Island cotton is considered to be the best cotton from the point of view of staple length and fineness. Its staple length is  $1\frac{1}{2}$  to  $1\frac{5}{8}$  inches. It is very fine and silky. It spins 70's to 80's and gives 30 per cent ginning outturn. This strain also has been recommended for East Sind.

*Gossypium hirsutum*—This is a group of cottons more commonly known in India as American cottons. It is a group introduced into different parts of India. In the Punjab this group includes—two or three well-known strains, Punjab 285F, Punjab 289F and Punjab 4F. More recent reports state that the new varieties of Punjab-American designated 43F and 38F have given better results in laboratory tests than the earlier ones. In Sind, selections were made from these Punjab strains and some have been found to be better than the imported parents. These are now designated as 4F-98 and 289F-1. In the Bombay Presidency this species of cottons is represented by a group known as Dharwar-American, of which the Gadag strains have been evolved. In Madras the *hirsutums* are commonly known as Cambodia of which one strain,

known as Coimbatore No. 2, is among the important ones. In several other parts of India these American cottons are found mixed with the indigenous cottons, such as the *Malan* in Central India, the Mysore-Americans in Mysore and *Buri* in the Central Provinces and Berar.

*Gossypium herbaceum*—This species of cotton includes the three varieties *typicum*, *frutescens* and *africanum*. The first is mainly confined to the countries to the north-west of India, and the last occurs chiefly in South Africa. So only one variety of the species *herbaceum* is found indigenous to India. In India this variety *frutescens* is mainly confined to the western coast extending from Cutch to Madras. This species is represented by such groups of cottons as those known locally as *wagad*, *lalia*, *Broach*, *kami*, *kumpta* and *uppam*.

The *wagads* are a group of cottons generally grown in the Ahmedabad district in North Gujarat and in parts of Kathiawar and Cutch. These cottons possess a staple length of about  $\frac{3}{4}$  to  $\frac{7}{8}$  inch, with a ginning percentage of 33. One chief peculiar characteristic of this cotton is that the bolls do not open even when ripe. This group has one particular defect when grown in this area and that is, it is very late in maturing and for that reason is usually subject to frost. *Wagad* No 8 has been for some years regarded as an improved type of this group of cottons. The *lalias* and *kamis* are mixtures of various strains of *G. herbaceum*. These are grown largely in North Gujarat, Kathiawar and some parts of Cutch. The staple lengths of *Kanvi* are  $\frac{1}{2}$  inch to  $\frac{5}{8}$  inch, whereas that of *lalia* is  $\frac{5}{8}$  inch to  $\frac{3}{4}$  inch. These mixtures vary in ginning percentage from 32 to 35. One undesirable characteristic of the *lalia* cottons is that the bolls open at maturity and allow the seed cotton (*kapas*) to fall to the ground.

Broach cottons are grown in the district of Broach and Surat. They usually possess a staple length of  $\frac{7}{8}$  to 1 inch. These cottons have a high value on account of their whiteness and glossiness, and have therefore acquired a high reputation in the cotton trade. Surat

1027 A. L. F. is one of the varieties of Broach cottons recommended to the cultivators. Its average staple length is about 1 inch and it spins 34's.

*Goghari* is a type of Broach cotton and is grown mostly in Gujarat, largely in the districts of Ahmedabad and Khaira. This is a high ginner, with a ginning percentage of about 40. On account of its high ginning percentage it has become popular with the cultivators but due to its short staple its invasion may cause the famous Broach cottons to deteriorate. Measures are therefore being taken to check its spread.

*Kumpta* cottons are generally grown in the Kumpta Dharwar Division of the Bombay Presidency, and in the Raichur district of the Hyderabad State. They possess a staple length of  $\frac{3}{4}$  to  $\frac{7}{8}$  inch, and a ginning percentage of 26. Dharwar No. 1 is a pure type of *Kumpta* cotton and is considered to be an improved type of the tract. Another strain of *Kumpta* cottons which is gaining in popularity in the area is known as Jayawant.

*Uppam* cottons are generally grown in Coimbatore and Trichinopoly districts of Madras. These cottons possess a staple length of  $\frac{3}{4}$  inch and a ginning percentage of 25.

*Gossypium arboreum*—This species of cotton is the most widely distributed in India. Three varieties of this species are now being recognized: (1) var. *typicum* which is a monopodial and perennial type, (2) var. *neglectum* which is predominantly sympodial and annual type, and (3) var. *cernuum* which is also sympodial and annual.

The variety *typicum* occurs mainly in Assam, Bengal, the Gangetic plain and Central India, Peninsular India, Kathiawar and Gujarat. The types of *typicum* confined largely to the first four regions mentioned are grouped by Hutchinson and Ghose under the designation of *forma bengalensis*, whereas those occurring largely in the last three regions are designated as *forma indica*. *Typicum* is not of very great agricultural importance.

The variety *neglectum* occurs in India in two forms which are also designated by Hutchinson and Ghose as *forma bengalensis* and *forma indica* respectively. The first form occurs largely in Assam, Bengal, the Gangetic plain, the Punjab, the North-West Frontier Province, Rajputana, Central India, Gujarat, Kathiawar, Khandesh and parts of the Central Provinces. The second form occurs in the region south of the Tapti river.

The variety *cernuum* is mainly confined to East Bengal and Assam. According to Hutchinson this variety has probably descended from the same parental stock as *neglectum forma bengalensis*. But the *neglectum* has spread from the hilly tracts of Bengal and Assam, almost throughout India within recent times when cheap cotton goods were made in England. This invasion of these coarse-stapled cottons is due to their high ginning percentage.

*Gossypium arboreum* var. *neglectum forma bengalensis* is represented in different parts of India by several types, of which the representatives are the following:

1. The *Malvi* cottons which are mainly grown in Central Provinces and Central India represent one of these types. Their staple length is  $\frac{3}{8}$  to  $\frac{7}{8}$  inch long with a ginning percentage of about 25. Through selection at Indore, considerable improvement has been made both in staple length and ginning percentage. Two important strains have been evolved, Malvi 1 and Malvi 9, the latter with a ginning percentage of 33. This superior strain is therefore being recommended to the cultivators of the area.

2. The *Roseum* cottons in the Central Provinces, Central India and Khandesh in the Bombay Presidency form another type of the *neglectum* cottons. Their staple length is  $\frac{1}{4}$  to  $\frac{5}{8}$  inch with a ginning percentage of 40. This group has one peculiar characteristic in its favour, and that is that its lint is always cleaner than that of the other varieties of *neglectum*, probably due to the way in which the bolls open.

3. The *Verum* cottons represent another group of the variety *neglectum*. They are grown largely in the Central Provinces and Berar. Their staple length is  $\frac{5}{8}$  to  $\frac{3}{4}$  inch with a ginning percentage of 30. The Agricultural Department of the Central Provinces has put out some strains of verums designated as *Verum* 262 and V—434 and late *Verum* which is now recommended to the cultivators. *Verum* 262 has a staple length of  $\frac{7}{8}$  inch. *Verum* cottons as well as the *Malvi* and *Roseum* cottons are grown to some extent in the United Provinces and the Punjab. The three types just mentioned are collectively known as the *Oomra* cottons.

4. The *Mollisoni* cottons are another well-known group in this country. They are mainly grown in the Punjab and parts of the United Provinces. These cottons possess white flowers and somewhat broad leaves. Their staple length is  $\frac{3}{8}$  to  $\frac{1}{2}$  inch with a ginning percentage about 40. *Mollisoni* No. 39 is an improved type recommended by the Punjab Department of Agriculture.

*Gossypium arboreum* var. *neglectum* forma *indica* represents another group of cottons in South India. They probably had a parallel evolution with the forma *ben-galensis* cottons of Northern India. They are physiologically different from their Northern India equivalents, and when grown in northern regions, they develop a bushy monopodial habit similar to that of the perennial type, var. *typicum*, from which they probably evolved. They are generally confined to peninsular India, south of the Tapti river. On both sides of the Tapti river the overlapping of these two forms of *neglectum* may occur. This results in the merging of the two forms with a consequent reduction in the distinction between the two forms. The two well-known forms of cotton which represent this group are those usually called the *Karungannis* and the *Banis* of Madras. The southern cottons, while they possess a longer staple length, are inferior to the northern in ginning percentage. *Karunganni* cottons are now grown mostly in the Tinnevely area in the Madras Presidency.

Their staple length is  $\frac{7}{8}$  to 1 inch, with a ginning percentage of about 30. C-7 and A-10 are two improved types of this group of cottons now recommended for Madura, Ramnad and Tinnevely districts, and C-7 for Coimbatore district also.

*Bani* represents another group of *arboreum* cottons grown in India. This group is mainly grown in Berar. This is one of the finest indigenous cottons. It has a staple length of about 1 inch and a ginning percentage of about 25. Its lint is strong and glossy. This group of cottons also goes under the trade name of *Oomras*.

*Gossypium arboreum* var. *cernuum* is mainly confined to East Bengal and Assam. The variety possesses very long bolls which are about 2 inches or more in length. The staple is very short,  $\frac{3}{8}$  to  $\frac{1}{2}$  inch, and the lint is very coarse. Its ginning percentage, however, is high, averaging from 43 to 50. This variety goes under the trade name of *Comilla*.

### CULTURAL METHODS

There are in general two methods of growing cotton in this country depending upon the two predominant soil types, the black cotton soils and the Indo-Gangetic alluvium.

**In the black cotton soil area**, which includes the Central Provinces, Central India, the Bombay Presidency excluding North Gujarat, Hyderabad State, Berar and parts of the Madras Presidency, the usual method is to stir the soil with a local cultivator (*bakhar*) several times during the hot weather. If manure is to be applied, this is also done during the hot weather, usually in May. After the first shower or two of the monsoon rains, the soil is thoroughly pulverized usually with a *bakhar*.

In this area cotton is usually sown in lines with a two-coulter drill. The distance between rows usually varies in different parts, commonly from 14 to 22 inches. The distance between rows depends on the type of cotton

grown and the fertility of the soil. Sowing is usually done in June, in the northern portion of this area and in August to October, in the Madras area. Before the seed is sown the usual method is to mix it with mud, or moist cowdung and ashes so as to make the fuzz adhere to the seed-coat. This treatment makes sowing more efficient; and by making the fuzz adhere to the seed-coat, the seed is brought into closer contact with the moist soil, and thereby germination is improved. The amount of seed sown varies from 10 to 20 lbs. per acre.

In Madras, cotton is sometimes sown as a mixed crop with horse-gram (*Dolichos biflorus*), Italian millet (*Setaria italica*) and with coriander (*Coriandrum sativum*).

After germination, the plants are generally thinned to 12 to 24 inches apart in the row, the distance between plants being different in different localities. During the thinning operation, "roguing" or the removal of off-type plants is carried on. These off-type plants are generally due to the mixing of seeds at the gin. It is therefore advisable not to sow seeds obtained from the gins if the variety is to be kept pure.

Interculture begins when the plants are about 4 inches high. This is done by a bullock drawn *dcara* or hoe, a method which is cheap and effective. A man with a pair of bullocks can cultivate about 4 acres a day. The number of cultivations during the growing period usually varies from two to four. In certain areas in the Bombay Presidency, the plough is passed between the rows in September or October as a final cultural operation, in order to prevent damage from cracking, a phenomenon which is common with this type of soil.

Picking in northern portions of the Bombay Presidency commences in January and continues until April or May. In the central portions of the province, picking begins in October and ends in December. But in the southern portions, picking begins in March and ends in May. In the Central Provinces picking usually begins

in October and continues till December, but under irrigation picking continues till March. In Central India picking takes place in December and January. Further south in the Madras area, cotton is picked from February to July.

In the alluvial soil area cotton is almost exclusively an irrigated crop, and thrives best on loam soil, but does well also on clay loams.

The preparation of a seed-bed consists in ploughing with the object of thoroughly pulverizing the soil. Before the seed is sown, planking is done in order to level the land and make the seed-bed firm.

The seed is sown either broadcast or in lines. The former is the more common practice. But the practice should be discouraged as it is very inefficient, thus making the cost of production high and also giving low yields.

Cotton is sown in April in most parts of the Punjab except in the south-west where it may be sown up till June. In the United Provinces cotton is sown in May and June with irrigation. In Sind, sowing is done in May.

Where cotton is sown in lines, the distance between rows for American varieties is usually about three feet and for local *desi* cottons about two feet. This distance, however, may be varied according to the soil conditions. On fertile soils the distance may be increased.

In certain areas of the Punjab cotton is grown along with a fodder crop such as *senji* (*Melilotus parviflora*), *shaftal* (*Trifolium resupinatum*) and *berseem* (*Trifolium alexandrinum*).

In the Punjab and the United Provinces, in broadcast sowing, weeding and mulching is done by hand with a *khurpi*; but when sown in lines, this may be done by a bullock-drawn hoe or cultivator.

The number of waterings given to a crop of cotton in this area varies with the amount and distribution of rain during the season. The first watering is usually given before sowing. If the germination is poor, irrigation may



be necessary a week or ten days after sowing. But this should be avoided if possible. If no rain occurs during the growing season, water may be applied at three week intervals, each watering to be followed by mulching and weeding. In the Punjab the number of irrigations most commonly given to American cotton is four to six, and to *desi* cotton three to five. The picking of cotton in the Punjab begins in October, and continues until the plants are killed by frost. In the United Provinces picking begins in October and continues till December.

#### DISEASES

The two most important fungous diseases which attack the cotton crop in this country are the cotton wilt in the black cotton soil areas, and root-rot in the alluvial soil areas.

*Cotton wilt* (*Fusarium vasinfectum*, Atk.)—The most characteristic symptom of the disease is the gradual drooping and withering of the plants. Either the whole plant or a particular branch may be affected. The drooping generally starts from the bottom upwards, the wilted leaves gradually becoming yellow and then brown. The disease may appear two weeks after sowing, but plants at all stages of their growth may be affected. Wilted plants, however, do not show any external discolouration or markings either on the stem or roots. But when the roots are split open it is found that the woody tissue is blackened in streaks. These discoloured streaks may extend to the small branch roots and also to the stems and branches.

The disease is carried within the seed, but when once established it may continue to live in the soil for several years. Where this disease occurs, it will be noticed that at first a few plants in the field may be attacked, but the circle widens year by year, until large blocks of infected soil are formed in which cotton plants are unable to grow to maturity.

The disease may be controlled by sowing seeds from areas known not to have the wilt disease. Where wilt

is prevalent, only wilt-resistant varieties should be grown. In general it has been found that American varieties of cotton are not very susceptible to the organisms which cause the wilt disease in Indian cottons.

*Root rot (Rhizoctonia sp.)*—This is one of the most serious diseases of cotton in the Punjab, Sind, Gujarat and the United Provinces, and is believed to be caused by two organisms—*Rhizoconia solani* and *Rhizoctonia bataticola*.

While the disease usually attacks the cotton plants in the seedling stage, mature plants may also be affected. The most important characteristic symptom of this disease is the sudden wilting of the plants. The leaves from top to bottom of such affected plants appear to have suddenly collapsed almost overnight. The disease, however, actually starts much earlier, and therefore the wilting or drooping of the leaves is a late symptom of the disease. Plants affected by this disease can also be uprooted much more easily as almost all the branch roots decay. If the roots of these affected plants are examined it is found that the tip of the root is moist and sticky, and leaves a yellowish stain on a white surface. The bark of the roots of these affected plants usually breaks down into shreds, whereas the woody portion remains unaffected, except for a slight yellow discolouration on the surface at the early stages of the disease and a brownish or black colour on the woody tissues at later stages.

The fungi which cause this disease live in the soil and therefore any treatment of the disease at present is impracticable. Rotation of crops has been suggested, but the disease is known to live in the soil for several years. As similar organisms cause the root rot of cowpeas and groundnuts, these two crops should not therefore be used in the rotation.

*Minor disease*—Other diseases which are usually less prevalent, but nevertheless do some damage to the cotton crop in this country, are the following: (1) *Anthracnose*, a disease which is caused by a fungus *Colletotricum* sp. This disease occurs in the Central Provinces and the Madras

Presidency. The disease first appears on the bracts as water-soaked circular spots and later spreads to the bolls and causes them to shed. (2) Mildew (*Oidium* sp) which occasionally occurs in the Bombay Presidency. (3) Leaf spot (*Mycosphaerella gossypina*) which occurs occasionally in most parts of India. (4) Rust (*Kuehneola desmium*). This also occurs in most parts of India.

### INSECT PESTS

The insects which do the most damage to the cotton crop in this country are the pink boll-worm, the spotted boll-worms, the white fly, the Jassids, the grey weevil, the red cotton bug and the stem borer.

*The pink boll-worm*—(*Platyedra gossypiella*, Saunders). This insect occurs throughout the plains of India and is a serious pest on cotton in the United Provinces and the Punjab.

This is a reddish caterpillar which feeds in the green or ripe bolls. The caterpillar at the early stages is whitish but possesses a dark head. When young, it feeds on the leaves or on the outside of the boll. After a few days it bores through the rind and begins to feed upon the seeds. The mature larva is slender and possesses bright pink spots on its body. When full grown the larva pupates in the boll or on the leaves of cotton. After pupating it emerges as a moth which resembles a clothes moth, and is of a dark brown colour. The moth flies at dusk and also at night and is readily attracted to light. Hence it may be caught in light-traps.

The insect may be controlled by fumigating the seed with carbon bisulphide or by exposing the seed to the hot rays of the sun. A temperature of 140° F. for a few minutes is all that is necessary to prevent any of the caterpillar from becoming moths. Where the damage is serious the first crop of bolls may be picked and destroyed.

*The spotted boll-worms*.—(*Earias fabia*, Stoll and *E. insulana*, Boisd). These two boll-worms are almost iden-

tical in shape, form and even in the damage they do to the cotton crop. All of the damage done by these insects is during their larval stage. The larva is a short thickish caterpillar about two-thirds of an inch in length. The colour of the body of the caterpillar is usually of a dull greenish white, with black and orange spots on the sides. At each segment there are tubercles with hairs. The young larva at first feeds on the leaves and bracts, but later on it enters the boll and feeds on the seeds, eating them one after another. When full-fed it pupates, and after some days it emerges as a moth. The moth is dark brown in colour, usually with a broad green band extending from the base to the apex of each wing.

The insects may be controlled by destroying the bolls and the shoots of young cotton plants which contain them. Another method of control is to grow *bhindi* (*Hibiscus esculentus*) as a trap crop. The *bhindi* plants are then uprooted and destroyed.

*The cotton white-fly*—(*Bemisia gossypiperda*, M. and L.) This insect was described for the first time in 1929 by Misra and Lamba working at Pusa. But the insect is quite common in the plants in the Punjab where the damage to the crop is reported to be quite serious. The attack of this insect is believed to be more serious on the imported varieties than on *desi* (local) ones. The adult fly is a very small insect, a little over 1 mm. in length (approximately  $1/24$  inch). The body is yellow and the wings are white. The damage to the crop is done by the larva sucking the juice out of the leaves. The larvae when newly hatched move about for some time, and then attach themselves usually on the lower surface of the leaf. It has been reported that sometimes as many as 250 insects per square inch of leaf were found on the cotton plant. The insect also attacks other crops such as cabbages, *bhindi*, tobacco, mustard, cucurbits and various other crops and weeds.

The insects may be controlled to some extent by prac-

tising clean cultivation and the removal of weeds.

*Minor insect pests*—Besides the three insects mentioned above, there are several others which damage the cotton crop in some parts of India to some extent. But as the damage done is not serious, they may only be mentioned here. Those are: (1) the Jassids (*Empoasca gossypii*) which are believed to be responsible for leaf curl and the "bronzing" of the leaves of certain varieties of cotton, (2) the cotton leaf roller (*Sylepta derogata*), (3) the woolly mites (*Eriophyes gossypii*) which are reported to be serious and widespread in certain parts of the Bombay Presidency, (4) the cotton stem weevil (*Pempheres* sp.), reported to be common in the Madras Presidency, (5) the stem borer beetle (*Sphenoptera gossypii*), which is common in Berar and in the district of Surat in the Bombay Presidency, (6) the red cotton bug (*Dysdercus cingulatus*), (7) thrips (*Heliothrips* Sp.) which are very minute insects, (8) red mites (*Tetranychus bioculatus*) and (9) apides (*Aphis gossypii*).

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## CHAPTER VI

### JOWAR

*Origin and history*—*Jowar* is one of the most important and commonly cultivated crops in this country. Its cultivation in this country has been carried on for several centuries. While the origin of this crop is generally attributed to tropical Africa, it seems very probable that some forms also originated independently in this country. At any rate the greatest variability of this crop is found in Abyssinia, the western parts of tropical Africa, Arabia and India. And while most investigators are of the opinion that the cultivated *jowars* have originated from Johnson grass commonly known in Northern India as *baru*, or its annual type, Sudan grass, Snowden in his recent monograph expressed an opinion that the cultivated *jowars* have arisen from the following four ancestral types: (1) *Sorghum arundinaceum*, (2) *S. verticilliflorum*, (3) *S. aethiopicum* and (4) *S. Sudanense*. According to this author therefore Sudan grass (*S. Sudanense*) is partially responsible for some of the cultivated sorghums.

The cultivation of *jowar* at present is, however, not confined to these regions, but is carried on in China, Australia and the warmer parts of the United States. While there are no statistics of the world production of sorghum, undoubtedly India ranks first.

*Distribution in India*—In India this crop is being grown in practically all the provinces, but the main areas of production are in the Bombay Presidency, the Madras Presidency, Hyderabad State, the Central Provinces and Berar, and the United Provinces.



TABLE 9

Showing the area and production of jowar (grain) in India.

Provinces and States	Area in thousand acres in		Yield in thousand tons in	
	1937-38	1940-41	1937-38	1940-41
Bombay .. ..	1,836	1,855	1,123	1,530
Madras .. ..	4,599	4,668	1,097	1,167
Hyderabad .. ..	8,480	8,840*	1,308	1,263
C. P. and Berar .. ..	4,248	4,533	1,061	1,133
United Provinces .. ..	2,232	2,224	436	445
Sind .. ..	439	494	109	120
Mysore .. ..	656	660	127	110
Punjab .. ..	838	876	89	87
Bihar .. ..	62	74	17	21
N.-W. F. Province .. ..	69	79	8	11
Orissa .. ..	38	44	12	8
Others .. ..	..	2,000	..	400

*Botanical description*—*Jowar* is an annual plant which belongs to the great family of grasses known as *Gramineae*, to which the important cereals belong. The plant varies in height with different varieties from 4 feet to 15 feet or more in some tropical forms. In habit and appearance the plant resembles maize (*makka*).

The stems or culms of *jowar* are cylindrical and jointed. The number of nodes is different in different varieties, and consequently the number of leaves and the length of internodes also vary with different varieties. The thickness of stems usually varies, the thicker ones being about one inch in thickness. Most of the *jowars* in this country do not tiller, but some introduced fodder varieties, however, are capable of producing three or more tillers from one plant.

The stems of *jowar* also vary a great deal with regard to their juice content. Some are quite juicy and sweet,

\* Approximately.

whereas some are pithy and contain very little juice. Certain introduced fodder varieties are more juicy and also sweeter than the common *jowars* of India.

The number of leaves in *jowar* varies with the number of nodes in the stems but the number is usually from 12 to 20. The leafy character is desirable for fodder varieties. Like the leaves of all grasses, a *jowar* leaf possesses parallel veins and a midrib which is generally white in colour. Some varieties, however, possess a dull-green midrib. It has been found that this character is associated with the juiciness of the stem.

The inflorescence of *jowar* is a panicle with varying degrees of looseness or compactness. Most of the grain *jowars* in India may be classed as compact, loose or intermediate. The broom corns (*Sorghum dochna* var. *technicum*), however, possess very loose and long panicles. The panicles are commonly known as "heads". These vary a great deal in size, shape, form and colour. The peduncle, commonly known as the "neck", may be straight, curved downwards, or half-bent. When curved downwards, it is usually known as "goose-necked". The panicle is composed of numerous spikelets which usually occur in pairs, one of them being sessile and the other pedicellate. The sessile one is broad thick, and fertile, whereas the pedicellate one is narrow, long and staminate, and hence does not form seed. However, the spikelets occur in threes near the top of the panicle, in which case one is sessile and fertile and the other two are pedicellate and infertile. Occasionally one of the pedicellate spikelets may become perfect.

Within the sessile spikelet two flowers occur, one fertile and the other sterile. Generally one grain is formed as the result of the fertilization of the fertile flower. Occasionally, however, more than one grain may develop, producing a phenomenon known as multiple-seededness. Ayyangar reports as many as six seeds in a single spikelet, but two is the most common. In this country these double-seeded grain *jowar* are known as "do-dania". This pheno-

menon of multiple seededness has been explained by Karper as being the failure of two or three carpels to fuse into a single pistil and the development of each with an independent ovary containing an ovule. Normally the carpels fuse into a single pistil, each carpel developing a fertile ovule. This development of additional functional flowers within the spikelet is probably responsible for the development of extra kernels.

The *jowar* flowers begin to open after the inflorescence has come out of the terminal leaf sheath which is known as the "boot". The first flowers to open are those near the apex, and blooming proceeds progressively downwards on the panicle. Normally the flowers are pollinated from the higher flowers of the same panicle. But natural crossing also occurs. According to Patel, under conditions prevailing at Surat in the Bombay Presidency, natural cross-fertilization takes place to the extent of 25 per cent. Graham, working in the Central Provinces, estimated the percentage of natural cross-fertilization in a loose paniced type as six per cent, and in a type with a compact panicle 0.6 per cent. One variety gave 20 per cent of crossed flowers. Karper and Conner working in America conclude from their investigations that "in actual field practice where a pure strain is grown near to, and flowering at the same time as another field which might contaminate it, the amount of crossing in the outer rows would undoubtedly not exceed 3 per cent."

*Jowar* possesses a well-developed root system similar to that of maize but generally wiry and more fibrous, and also usually more abundant. Most of the roots are confined to the upper  $1\frac{1}{2}$  feet of soil, but in the later stages of development they may reach a depth of  $4\frac{1}{2}$  to 6 feet. The roots are widely and thickly distributed and their absorptive power is so efficient that it is able to exhaust most of the available moisture from the soil.

*Ecological factors*—*Jowar* in this country is grown mostly as a *kharif* crop. In Western India and in Madras it is also grown as *rabi* crop. Its cultivation in this country

is mainly confined to those regions where the annual rainfall is not more than 40 inches. In regions with a heavier rainfall the crop is usually replaced by rice. Its water requirement is less than that of maize, and consequently *jowar* is grown as a fodder in regions which may be called semi-arid and where maize will not do well. This peculiar adaptability of *jowar* to dry hot regions is probably due to (1) the high degree of resistance of the plant to injury from dry hot weather, and (2) its ability to stop growing during an unfavourable period for growth, and then to renew growth under favourable conditions without any apparent injury to the crop.

*Jowar* is generally considered to impoverish the soil. This may be due to (1) the fact that its root system is concentrated on the upper soil layers to a greater degree than other crops, thus resulting in the exhaustion of the surface soil of its available plant nutrients, and (2) the rendering of available nitrogen unavailable by the action of cellulose-decomposing bacteria during the decay of the sorghum roots and stubble. Whatever the reasons may be, the depressing effect of *jowar* is usually temporary and most pronounced on the succeeding crop, completely disappearing in a year or two. The depressing effect is least noticeable with legumes and most pronounced with cereals.

Whereas *jowar* is generally grown on all kinds of soil, it does not thrive in sandy soils, and does better on heavier types.

*Classification of jowars*—The cultivated sorghums of the world have been classified in various ways by different investigators. Ball, in America, classified the sorghums mainly on the basis of the character and quantity of the juice in the stems and on the character of the panicle, whether loose or compact. In India several attempts were made to classify the *jowars* in the various provinces, such as those by Benson and Subba Rao in Madras, Kottur in the Bombay Presidency and Sabnis in the United Provinces.

Recently Snowden has classified all the cultivated

racess of sorghum into six sub-series as follows: (1) *Drummondii*, (2) *Guineensia*, (3) *Nervosa*, (4) *Bicoloria*, (5) *Caffra* and (6) *Durra*. According to him the Indian sorghums fall into the sub-series *Guineensia*, *Nervosa*, *Bicoloria* and *Durra*. *Sorghum Roxburghii* is the only one belonging to the sub-series *Guineensia*, *S. membranaceum* is the only one belonging to the sub-series *Nervosa*, *S. dochna*, *S. bicolor* and *S. milliforme* belong to sub-series *Bicoloria* and *S. durra*, *S. cernuum* and *S. subglabrescens* belong to the sub-series *Durra*. The value of Snowden's classification for the identification of the cultivated *jowars* of India is rather questionable.

#### CULTURAL METHODS

The preparation of the land for the sowing of *jowar* is not as thorough as for most of the cereals. In the black cotton soil area, if the land is badly infested with weeds, ploughing followed by harrowing is usually practised. Where ploughing is not necessary, the land is cultivated with the *bakhar*. In the alluvial soil area the land is usually ploughed two or three times before sowing. In Northern India when the monsoon sets in, the seeds are sown either by broadcasting or in rows behind the plough. Sowing in rows is common in the black soil area whereas broadcasting is practised in the Indo-Gangetic alluvium. In the south two crops of *jowar* are usually grown during the year. The "early" crop is sown at the beginning of the south-west monsoon, and the late *jowar* is sown near the end of the south-west monsoon.

When sown in lines the distance between the rows varies from 14 inches to 2 feet, usually depending on the character and fertility of the soil. The plants are usually thinned to a spacing of about 9 to 12 inches in the row. The seed rate varies from 5 to 10 lbs. per acre or an average of about 8 lbs.

*Jowar* does not usually require any special care after sowing, except an occasional weeding. In the black soil area, weeding is usually done by means of a bullock-drawn

hoe known as a *daura*. In the Indo-Gangetic alluvium weeding is usually done by hand by means of a *khurpi*.

When *jowar* is grown exclusively for fodder purposes the seeds are usually broadcast. The amount of seed sown per acre is also greater, ranging from about 25 to 30 lbs. per acre. In fodder *jowar*, no thinning or weeding is ordinarily done.

When grown for grain, the crop is left in the field until the grains are fully mature. The stalks are then cut as close to the ground as possible by means of sickles. They are then tied in bundles and brought to a threshing floor where the heads are cut off and the stalks are stacked. When the heads are thoroughly dry, they are heaped on a threshing floor and the bullocks are made to tread out the grain. The grain is finally separated from the chaff by winnowing. The stalks are usually cut into small pieces collectively known as *kadbi*, which is used for feeding to cattle.

The fodder *jowar* is usually cut when the plants are still green, preferably when the grains are in the "dough" stage. This is cut up almost immediately by means of a handchopper known as a *gandasa*. After cutting, the green *kadbi* is fed to cattle. This method of feeding green fodder to cattle is known as "soiling". Such a crop is therefore known as a "soiling crop". On the other hand if the green fodder is put into an air-tight chamber or pit and allowed to ferment, the fermented material is known as silage. Such chambers or pits are known as silos. These may be constructed above or below ground level.

#### DISEASES AND INSECT PESTS.

*Red leaf spot (Colletotrichum graminicolum)*—This is probably one of the most common diseases of *jowar* in India. The disease causes small red spots which are visible on both the upper and lower surfaces of the leaf. When the spot has fully developed, the central area is usually lighter in colour. In this central area one or more black dots may be seen on both sides of the leaf. The disease,

while common, does not seem to do much damage to the crop. So far as is known, no control measures for this disease have been worked out.

*Rust (Puccinia purpurea)*—This disease is fairly common in *jowar*, but the extent of its damage has so far been imperfectly estimated. The disease appears on the leaf as bright purplish spots, the purple colour being more intense near the edges. At first the disease is inside the epidermis which later bursts and exposes a light-brown powder which is composed of the spores of the fungus.

Although the disease is found in all parts of India its occurrence in epidemic form varies in different localities and with the atmospheric conditions of the weather.

*Minor diseases*—The *jowar* plant is also subject to the attacks of a number of diseases which are of minor economic importance. Some of the common ones are: (1) a leaf spot disease caused by *Cercospora sorghi*, (2) downy mildew (*Sclerospora graminicola*), a disease which is more common in *bajra* than in *jowar*, (3) grain smut, perhaps the commonest smut of *jowar* in India and caused by *Sphaecelotheca Sorghi*, (4) head smut, caused by *Ustilago Reliana*, (5) loose smut, caused by *Sphaecelotheca cruenta*, (6) long smut caused by *Tolyposporium filiferum*, and (7) blight and hollow stem caused by *Macrophonima phaseoli*.

*Insect pests*—The insect enemies of *jowar* are not as numerous as those of sugarcane. But certain insects which attack the sugarcane crop also attack the *jowar* crop. Thus the stem-borers which were described under sugarcane may also be found attacking the *jowar* plants. Therefore the methods of controlling stem-borers in sugarcane fields may be adopted for the control of these when they occur in the *jowar* fields.

Other insects of minor importance which attack *jowar* are the blister beetles which feed upon the flowers. These are usually known in three forms: (1) the orange-banded blister beetle (*Mylabris pustulata*), (2) the green blister beetle (*Cantharis tenuicollis*) and (3) the brown blister beetle (*Cantharis rousci*).

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## CHAPTER VII

### TOBACCO

*Origin and history*—Tobacco belongs to the family of plants known as *Solanaceae* to which some of our important food crops such as the potato, tomato and chillies belong. Tobacco belongs to the genus *Nicotiana*, but only two species, *Nicotiana tabacum* and *N. rustica*, are used for the manufacture of the tobacco of commerce.

The genus *Nicotiana* is believed to have originated in America. About fifty or more species are contained in the genus, of which the species *tabacum* above mentioned is the chief source of the tobacco of commerce. *N. rustica*, a species which is chiefly grown in Bengal, is another source. The introduction of tobacco into India was made by the Portuguese more than 300 years ago. Its cultivation extended rapidly, and at present the total acreage under this crop is about a million and quarter acres, with a total production of over a thousand million pounds. India is now the second largest tobacco-growing country in the world. Most of this is consumed locally in India in the form of "biri", cigarettes, "hookah" or pipe tobacco, or as cheroots. Cigarettes, however, are now replacing the "hookah" and a number of factories have been established to supply the growing demand. The present policy in India is to develop the cultivation and treatment of tobacco so that India may to some extent take the place of the United States in the supply of tobacco to England.

*Distribution in India*—Tobacco is grown in all the provinces of India, but the greatest centres of production are in the Rangpur district of Bengal and the Guntur

district in Madras. It is also, to a considerable extent, grown in the Muzzafarpur, Purnea and Darbhanga districts of Bihar; in the Jalpaiguri, Chittagong, Dacca, Jessore and Hooghly districts of Bengal; in the Mainpuri, Etah, and Farrukhabad districts of the United Provinces; in the Jullunder district in the Punjab; in the Peshawar district in the North-West Frontier Province; in the Kaira and Belgaum districts of the Bombay Presidency; and in the Coimbatore and Vizagapatam areas and also the Godavari delta of the Madras Presidency; and in the Goalpara district in Assam. The following table gives the area and yield of tobacco in the different provinces and States in India.

TABLE 10  
Showing the Distribution of Tobacco in India.

Provinces and States	Area in thousand acres in		Yield in thousand tons in	
	1937-38	1940-41	1937-38	1940-41
Madras .. ..	294	311	125	136
Bengal .. ..	313	321	130	134
Bombay .. ..	170	173	44	80
Bihar .. ..	125	108	52	43
United Provinces ..	88	73	63	48
Punjab .. ..	71	61	29	21
Hyderabad .. ..	63	68	17	16
Assam .. ..	12	15	6	6
Baroda .. ..	53	49	9	7
Central Provinces ..	12	9	4	3
Mysore .. ..	24	25	3	3
Sind .. ..	5	6	2	2
Others .. ..	58	94	27	40

*Botanical description*—The tobacco plant is a herbaceous annual. *N. rustica* is sometimes reported to behave as a perennial. The tobacco plant grows generally from 3 to 5 feet high. The stems are more or less round, and sometimes produce branches near the base which are known

as "suckers." The length of the internodes also varies in different types. Shaw and Kashi Ram recognize three types of internodes as short (below 2 cms.), medium (2-5 cms.) and long (more than 5cms.)

The leaves vary a great deal in number, shape and texture. Tobacco leaves may or may not possess leaf stalks (petioles). The plants of *N. tabacum* may or may not possess petioles, but those of *N. rustica* are petioled. The number of the leaves varies greatly. If the leaves are few, the plant has an open appearance, whereas if the leaves are numerous the plants have a bushy appearance. The shape of the leaves may be elliptical, lanceolate or ovate. The leaves in *N. tabacum* may sometimes be 3 to 4 feet in length. The texture of the leaves also varies in different types. In general the texture of the leaves of *N. tabacum* is finer than that of *N. rustica*, which is more or less leathery and tough. The leaves vary in the angles which they make with the stems. In some cases the leaves occupy a very upright position, the angle of insertion being small, while in others the leaves may be practically horizontal or they may bend at various points, *i. e.*, at the base, in the centre or at the tip.

The inflorescence of the tobacco plant is a terminal panicle. It may occur very close to the upper leaves or it may be much raised above them. The flowers are usually about 2 inches in length and are either pink, yellow, purplish or white. Those of *N. tabacum* are usually pinkish, whereas those of *N. rustica* are white or yellow. The pink colour in the flowers of *N. tabacum* may sometimes fade, leaving them white. The length of the flowers in *N. rustica* is more or less constant, whereas in *N. tabacum* it is quite variable. The width of the flowers of *N. rustica* varies from about 10 to 15 mms. at the maximum width of the calyx.

In tobacco plants, self-fertilization is common but cross-fertilization does occur, especially when the plants are grown in close proximity. The amount of natural cross-fertilization under field conditions in this country

has not as yet been determined. Howard is of the opinion that, since the stamens are arranged in close proximity to the stigma in the flowers of *N. rustica*, probably less natural cross-fertilization takes place in this species.

The root system of a tobacco plant is quite extensive and fibrous.

*Ecological factors*—Although tobacco is grown all over India, the crop does best where the structure of soil is sufficiently open for rapid root-development. The tobacco soils are therefore usually those considered as light soils. Usually rich soils, that is, those containing plenty of organic matter and nitrogen are not considered the best type of soils for cigarette tobaccos, for the smoke produced by tobaccos grown in such soils is usually objectionable, although the yields may be heavy. However, heavier grades of tobacco are grown in relatively fertile soils. A tobacco soil is therefore one that is relatively poor in humus contents, but contains a good amount of potash, phosphoric acid and iron. Tobacco also will not do well in water-logged soils, due probably to the deficiency of aeration or the development of harmful fungi and bacteria under such conditions.

Of the two species of tobacco, *N. rustica*, under cultivation, requires a shorter growing period. It is therefore more commonly grown in the drier, colder regions of north-west India and also in East Bengal where the growth is shortened by floods coming towards the end of the rainy season. The other species, *N. tabacum* is grown largely in Bihar and parts of Bengal and also in Madras and Bombay.

*Classification of the Indian tobaccos*—Indian tobacco as mentioned above consists of two species, namely, *N. tabacum* and *N. rustica*. The distinguishing characteristics of these two species may be stated as follows:—

*N. tabacum*—Leaves sessile or petiolate; in the latter case the petiole invariably winged. Flower pinkish. Grown practically all over India and supplies the major portion of the tobacco of commerce.

*N. rustica*—Leaves petiolate. Flowers yellow or white. Widely cultivated in Bengal and the northern parts of the country almost entirely for *hookah* tobacco.

The species *N. tabacum* has been classified by Prof. Comes of Naples (Italy) into six varieties. But his classification has been severely criticized by Anastasia, who reduced the number of varieties to four. In India, Howard and Howard have classified *N. rustica* into 20 different types and *N. tabacum* into 31 types. More recently Shaw and Kashi Ram have further added 18 types to those of Howard and Howard.

#### CULTURAL METHODS

*Seed-bed preparation*—Tobacco seeds, on account of their very small size, are not usually planted directly in the fields, but are sown in seed beds. The seed beds should be located on high well-drained soil. These seed beds should be thoroughly ploughed and cultivated for several months before the seeds are sown, in order to remove all the weed seed that might germinate with the tobacco seeds. The beds should be highly manured, preferably with oilseed cakes or rich leaf mould which should be well mixed with the soil. The land is then made into small raised beds which should be about 4 to 5 feet wide and separated by drains about 1½ to 2 feet wide and 4 to 6 inches deep. These narrow beds allow work to be done from the sides, and thereby tramping is avoided. The drains between the beds serve both for drainage and as footpaths. The seed beds are made slightly sloping from the centre towards the drains, in order to drain off the rain water.

The seed is mixed with fine sand or wood ashes and evenly broadcast on the seed beds. This mixing of the seed with sand or wood ashes ensures an even distribution over the whole area. After sowing, the seeds should be pressed in with a light roller. This compacting of the surface soil serves to bring the seeds into closer contact with the soil moisture, resulting in better and more uniform

germination. It should be remembered that an ideal seed-bed is one that is moist but not wet. The amount of seed necessary for sowing an acre is only  $\frac{1}{5}$  of an ounce. That is, one ounce of seed is all that is necessary for planting  $\frac{1}{5}$  acres of tobacco. In order to protect the young seedlings at their early stages from heavy rains or from intense sunlight, a *chupper* (thatched roof) supported on bamboos is generally constructed. The *chupper* later on is removed during the day, as otherwise the seedlings may become weak or suffer from a disease which generally attacks the plants at this stage and which is known as "damping off". If the seedlings are too crowded, they should be thinned in order to get stocky plants for transplanting. In case weeds appear, they should also be removed. Occasionally the beds should be mulched or cultivated by means of a sharp-pointed peg.

*Transplanting*—The field where the seedlings are to be transplanted should be thoroughly ploughed, cleaned and made free from weeds. Several ploughings may be necessary in order to break down the soil to a very fine tilth. When the seedlings possess four to five leaves, they are ready for transplanting into the field. The transplanting of seedlings should be done with care. The roots system should not be damaged more than is necessary, and the seedlings should not be exposed to the sun after removal from the seed-bed and before planting. In order not to injure the roots too severely, the seed-beds are generally watered 8 to 12 hours before the seedlings are to be removed. The seedlings should be removed by levering up with a flat-pointed stick or *khurpi* (trowel). In this way some soil will remain adhering to the roots. The seedlings are then laid on moist gunny bags or in shallow baskets. The gunny bags or the baskets are sprinkled from time to time with water in order to keep them moist until they are taken to the fields for planting. The seedlings are planted in the fields two feet apart in lines which are three feet apart. The transplanted seedlings should be watered immediately. When transplant-

ing, care should be taken not to cover the growing shoot with soil, which may prevent its growth. The seedling should be watered again the next morning. After transplanting, gaps usually occur which are caused by plants dying from various causes. These gaps should be refilled as soon as possible in order to ensure a good and uniform "stand".

*Care after transplanting*—About a week after transplanting, shallow cultivation should be given. This operation will help to kill the weeds which may have started and will also pulverize the soil. A fortnight later, another shallow cultivation should be given. Subsequent cultivation, if required, should be somewhat deeper. In Bihar this latter operation is sometimes done by means of a spring-tooth cultivator which does the work very effectively.

For tobacco leaf of better quality, "topping" is necessary. This operation consists in the removal of the terminal bud which produces the inflorescence. This is done by nipping the inflorescence between the thumb and the forefinger without causing too much injury to the plant.

By this operation nourishment which would otherwise have been used up by the inflorescence is directed to the leaves. For coarser tobacco this operation is generally done when 8 to 10 leaves have been formed; but for finer quality tobacco, the plants are topped when 14 to 18 leaves have been formed.

About a week after topping, branches known as "suckers" develop in the axils of the leaves. It is important that these should be removed before they exceed 2 inches in length, as otherwise much nourishment will be taken up by them which should go to the leaves. Usually two or three suckering are required before the plants ripen. This operation is also done by "pinching off" as in topping.

In carrying out these various field operations, great care should be taken not to injure or damage in any way.



the leaves that are left on the plant as the injured leaves produce a low quality tobacco leaf.

*Harvesting*—The ripening of tobacco plants usually begins six to eight weeks after topping, the length of the period varying with the season and local conditions. When the plants begin to ripen the leaves become yellow and somewhat mottled, droop slightly and become gummy and stiffer. The leaves should be picked when they are fully mature. Picking should begin with the lower three or four leaves at the base of the plant. These are usually the first to ripen and are known as “primings”. These are cured and usually sold as lower grade tobacco. Ripening proceeds gradually upwards. It is therefore advisable to have two or three pickings from one field, the first picking consisting of the removal of the lower leaves, and the last picking being of those of the topmost leaves on the plant.

*Curing*—The curing of tobacco consists in withdrawing the moisture from the leaf in such a way as to leave the proper colour and aroma in the dried leaf. In this country three methods are now generally followed in order to accomplish this. They are known as ground-curing, rack-curing and flue-curing methods.

The ground-curing consists of simply drying the tobacco on the ground. The leaves are spread on the ground every morning and collected in heaps every evening. This is a very primitive method and is unsuitable for the production of good quality tobacco.

Rack-curing consists of hanging the leaves on bamboo frames covered with a grass roof. This process takes at least six weeks for curing, and is unsatisfactory for the production of a high quality cigarette tobacco.

Flue-curing is the most satisfactory method for the production of a high quality cigarette tobacco. This method consists of hanging the tobacco leaves on racks in a barn under controlled conditions of temperature, air and moisture.

## DISEASES

*Mosaic*—This disease is caused by a virus which, as has been mentioned before in connection with sugarcane, is an ultra-microscopic body. The disease is highly infectious, and produces mottling on the leaves, that is, certain light-coloured patches appear on the leaves alternately with dark green areas, with a more or less sharp line of demarcation between the two. The disease also causes crumpling of the leaves. The substance causing the disease is present in the sap of a diseased plant; and if this sap is transferred to a healthy plant the latter becomes infected. Persons working in a tobacco field coming in contact with diseased plants may transfer the disease to the healthy plants by merely touching them. The sap carried from a diseased plant on the point of a needle is sufficient to cause the disease if brought in contact with the healthy plant. Even insects going from one plant to another can transfer this disease from plant to plant.

The best method of control of this disease is to pull out all infected plants as soon as the disease is detected. Persons handling diseased plants should not touch healthy ones. Another important method of controlling the spread of the disease in the field is the thorough washing of labourers' hands with a disinfectant at regular intervals.

*Wilt* (*Bacillus solanacearum*, Smith)—This disease occurs annually in the Rangpur district of Bengal, where it is known by the local name of "*rasa*". The symptoms resemble those of other wilt diseases, the plant undergoing progressive withering and wilting. Stems and midribs of the leaves of infected plants have dark brown streaks. The stems and main roots become discoloured and partly rotted near the ground. When the stems are split open, a dark brown discoloration is noticed which extends from the surface into the pith. The infection is believed to take place through injury caused either mechanically through the process of transplanting or cultivation,

or by means of insects such as Nematodes which bore into the roots or collar of the plant.

So far as is known no control measures can be adopted, and no varieties resistant to this disease have been evolved.

Other diseases known to occur in tobacco in India are the leaf spot (*Cercospora Nicotiana* Ell, and Ever.) and the mildew (*Erysiphe Cichoracearum* D. C.).

### INSECT PESTS

*Tobacco stem borer*—(*Gnorimoschema belioxa*, Low).—This is one of the most serious insect pests of tobacco. The adult is a small brown moth with narrow wings which are fringed, and is very similar in appearance to many small moths which commonly occur in fields in this country. But the damage is done by the larva of this moth which is a small whitish caterpillar about one-third of an inch in length. The caterpillar tunnels into the main stem, causing a gall-like swelling where it pupates. No control measure for this insect has been developed.

*Tobacco caterpillar* (*Prodenia littoralis*, Boisd)—This is another very common insect of tobacco. But whereas the stem borer attacks the tobacco stems, this caterpillar feeds on the leaves, and can also eat into the soft juicy stems. This caterpillar is also a serious pest of many other crop plants such as cabbage, potatoes, groundnuts, sweet potatoes and lucerne. The caterpillar when full grown is about 1-4 inches long, and is dark brown in colour. It pupates in the soil in which it burrows, and then forms a compact earthen case around its body.

The insect may be controlled by the application of arsenical sprays, but these should be applied only during the earlier stages of growth, as otherwise some of the poison may be left adhering to the leaves. The moth is not specially attracted to light, so light traps cannot be used to control this insect.

*Other insect pests* of minor importance which commonly attack the tobacco crop in this country are the green

caterpillar (*Chloridea assulta*, Guen.) and crickets (*Brachytrypes achatinus*, Stoll).

The tobacco plant is sometimes attacked by a parasitic weed known as broom-rape (*Orobanche* sp.). This plant is almost all flowers and possesses no leaves. So it gets nearly all its nutrition from the tobacco or any other plant on which it is a parasite.

The parasite may be controlled to some extent by not permitting it to flower and produce seeds. Where the fields are badly infested with this weed, a long rotation which does not contain any host plant for it should be adopted.

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## CHAPTER VIII

# POTATOES

*Origin and history*—The potato is one of the most important food crops of the world. Its growth in this country, however, is limited, although it is one of the most common of our vegetable crops. The plant belongs to the same family as tobacco, and is of the same genus as the brinjal or egg-plant.

The potato is believed to have originated in the higher regions of the western coast of South America, namely, in the tableland of Peru and Bolivia, and in the islands of the western coast of Chile. The plant was introduced into Europe very soon after the discovery of America.

The first mention of it in connection with India, according to Watt, is in the account of a banquet at Ajmer given to Sir Thomas Roe in 1615. It appears therefore that potato cultivation began in India not very long after the discovery of America.

*Distribution in India*—Potato in this country is grown in the hilly regions and also in the plains within access of the great markets of large cities and towns. In the United Provinces, the great centres of potato cultivation are the mountain regions of Naini Tal, Almora, Mussoorie, and in the plain regions in Farrukhabad and the vicinities of large cities such as Lucknow, Cawnpore and Allahabad. In Bengal, the potato is grown near Darjeeling, and in the districts of Jalpaiguri, Rangpur, Hugli and Burdwan. In the Punjab, the centres of potato cultivation are the Kullu and Kangra valleys and the Simla hills. In the Bombay Presidency, the main crop of potato is grown in the Poona district. In Assam, most of the potato crop is grown in the Khasi and Jaintia hills. In the South,

the crop is mainly grown in the Nilgiri hills in the Madras Presidency.

*Botanical description*—The potato plant is a herbaceous annual. It may stand erect or become procumbent or even prostrate. The aerial stems are round or angular, pubescent or glabrous, green or purplish, the anthocyanin pigment in the stem being usually present when the tuber is coloured. The swollen underground stems are known as “tubers”. These, it should be remembered, are morphologically stems and not roots, since in common with all stems of other plants, these tubers possess “eyes” which are buds from which stems are developed.

Potato leaves are pinnately compound with more or less petioled leaflets. The shape, size and spacing of the leaflets are all different in different varieties.

The inflorescence of the potato plant is borne on a primary axis which usually divides into two secondary axes. Occasionally the two axes divide again resulting a compact racemose types of inflorescence.

The flowers are more or less regular and are perfect. They vary in colour from purplish to almost white, depending on the variety. Most varieties of potato bear infertile pollen, so fruits or berries do not generally form. Potato flowers also produce no nectar and are therefore rarely visited by insects. Hence self-fertilization is natural to the species.

The roots of potato are small and fibrous, and extend downwards to a depth of about 3 to 4 feet and spread horizontally about 2 feet or more from the plant. Most of the root system is near the surface.

*Ecological factors*—The potato is essentially a cool climate crop. In this country the crop is grown in the summer in or near the hills where the temperature is low. In the plains it is grown during the cooler part of the year.

The best types of soil for the growing of potatoes are loams, and peaty soils. But the soils should be well drained and not alkaline in reaction. Slightly acid soils are preferable for potato cultivation, especially in areas

where a disease known as "scab" is prevalent. Heavy soils are unfavourable for the development and growth of tubers.

*Classification*—In other countries many schemes of classification of the potato varieties have been devised, but none of these can be of any use to India. The number of varieties of potato grown in this country is not very large, and no scheme of classification of these varieties has been devised. In the plains of India the most common varieties grown are: (1) *Gola*, a round and medium-sized, rough-skinned and brownish potato, the seed of which variety is obtainable from Dehra Dun and Quetta, (2) *Phulwa*, a whitish potato which produces light purple flowers in large numbers, and is grown extensively in the Farrukhabad district in the United Provinces, (3) *Surkha* or Patna, a pink-skinned variety, with good flavour, and consequently a variety that is extensively grown in the plains. In the hills the varieties grown are those imported from Europe, that have been acclimatized in this country. These hill varieties are also grown in the plains as a late crop.

#### CULTURAL METHODS

*Seed-bed preparation and planting*—In the plains, the preparation of the soil for the growing of potatoes consists in ploughing the land several times in order to produce a well-pulverized seed-bed. The field should be cleaned of all trash and weeds. This preparation of the soil is usually begun six to eight weeks before the sowing operation. During this preparation about 50 cart-loads per acre of well-decomposed farmyard manure are applied to the soil. The land is then prepared for irrigation before sowing is done. The field is laid out into strips about 6 feet wide, divided by water channels which run from the main channel, on the highest portion of the field, down the slope to the edge of the field. The strip of land about 6 feet wide is then divided into ridges and furrows 18 inches apart, the ridges being perpendicular to these water channels. These channels should



be on the upper side of the strip. Another modification of this is to make ridges and furrows 18 inches apart, these furrows starting from the main or secondary water channels and running down the slope to the edge of the field. When this latter method is adopted, one should be careful to see that the slope is not too steep, as otherwise erosion may take place when irrigation water is applied. The seed potatoes are usually put in about three inches deep and six inches apart on the ridges. For early sowing, whole tubers of small size are generally planted, the seed rate varying from 8 to 12 maunds per acre, depending on the size of the tubers. For late potatoes, the tubers which are much larger, are cut into pieces each having two or three "eyes" or buds, and are planted. The cut pieces are not usually sown for early potatoes as the conditions then are such that the cut pieces may rot. The seed rate for cut pieces is usually 6 to 8 maunds per acre. The seed used for the late sowing of potatoes is generally obtained from the hills. This is necessary because the potatoes of the early harvest in the plains will not germinate, as, normally, matured tubers have a natural resting period or period of dormancy, during which time they will not sprout even when planted under favourable conditions. It is also desirable because better varieties may be grown than will succeed early in the season. The practice of sowing extremely small tubers in this country is sometimes criticized as it is believed to result in the deterioration of the variety. While small seed potatoes obtained from a variety that normally produces large-sized tubers are not likely to produce a great percentage of small tubers, yet the continuous use of small seed potatoes probably has a tendency to cause the variety to deteriorate, as this method is a natural selection for potato plants producing small-sized tubers.

*Care after planting*—In the plains, the usual method is to irrigate the crop four or five times during the growing season, the number usually depending on the amount of moisture available in the soil and on the climatic condi-

tions of the locality. The first irrigation is generally given ten to fifteen days after planting, preferably after the sprouts have come out of the soil. Weeding and cultivating usually follow each irrigation.

When the plants are about six to eight inches high the first earthing up is done. This process consists of taking soil from both sides of the ridge and covering up the lower portion of the plants. This may be done in several ways. But the most common method in India is to earth up by means of *pharwas* or *kodalis* (large indigenous hoes). Some progressive farmers sometimes use an ordinary ridging plough or a three-row ridger for this operation. The second earthing up is usually done before the tops have become large enough to be damaged during the operation.

*Harvesting*—The best time for harvesting potatoes is when the tubers are fully ripe. This is indicated by the natural yellowing and drying of the leaves. In this country, a potato crop usually takes about four months to reach maturity. Sometimes potatoes are “lifted” or dug before they reach full maturity in order to take advantage of the higher prices in the early part of the season. Such potatoes do not keep well, and for this reason should be disposed of immediately. Potatoes when left to reach full maturity usually develop a thicker skin (periderm) which is more resistant to injury and which can therefore be kept longer or shipped greater distances. The deposition of certain waxy substances in the periderm (suberization) makes the fully matured tubers more resistant to drying conditions during storage.

*Storage*—Potatoes meant for seed purposes must always be kept for some time before sowing. Sometimes it also becomes necessary to store potatoes which are meant for sale in the market, before they are sold. During this process of storage, there usually results a considerable loss both in quantity and in quality. In the plains of India, it is difficult to store potatoes for seed purposes. Hence several methods for storing potatoes have been tried in

this country, but so far with very little success. One of the methods usually adopted is to store potatoes in coarse dry sand, but this is not always successful as the range of loss may vary from 40 to 90 per cent and at times even more than this. Cinders and charcoal have been substituted for sand without very much success. It appears that the storage of potatoes under low temperatures is perhaps the best known method at present. This method of storing potatoes under low temperatures while fairly common in western countries is not practicable in the plains of India. For the present it seems better that seed potatoes be grown and stored in the hills where the temperatures are usually lower than in the plains. Wherever potatoes are stored, it is necessary that the individual tubers be examined at short intervals, and that the decaying tubers be removed.

#### DISEASES AND INSECT PESTS

*Late blight (Phytophthora infestans)*—This is perhaps the most serious disease which attacks the potato in this country. Its appearance in the plains has been sporadic, although it is believed to be always present in some potato fields on the hills. The first appearance of the disease consists of small brown patches on the leaves. Under favourable conditions the disease spreads very rapidly, covering almost the entire surface of the leaf and may even spread to the stalks, resulting in the collapse of the plants by rotting off. The underside of the infected leaf develops webs of white, sporulating conidiophores. The disease becomes most virulent and epidemic in warm humid weather. Rains during the Christmas season followed by foggy weather will produce this disease in an epidemic form in the plains of India if it is present. The underground portions of the plants are also attacked. In fact, usually this is the first portion to be attacked, the above ground portions being attacked only under very favourable conditions. Such infected tubers if cut open show rusty brown markings beneath the skin. The disease is usually

carried over in tubers which infect the succeeding crop.

The method of preventing the occurrence of this disease in the plains is not to plant seed from those places on the hills' where the disease is prevalent. If seed from such localities is secured for sowing in the plains, it is advisable to get them early, so as to allow them to pass a portion of the summer in the plains, as the fungus causing the disease is believed to be killed at high temperatures such as occur during the summer in the plains of India.

Where the disease is prevalent the spraying of potato fields with Bordeaux mixture is the most common method of controlling the disease.

The growing of potatoes on the same land year after year where the disease is common is not to be recommended.

*Ring disease or bacterial wilt* (*Bacillus solanacearum*, Smith.) This is probably the most common and widespread potato disease in the plains of India. It has also been reported to occur in the hilly regions where potatoes are grown. The disease is caused by the same organism as that which causes the wilt in tobacco. The damage to that crop caused by this organism has already been dealt with in a previous chapter.

The disease causes a sudden wilting of the plant. Usually the lower leaves are the first to collapse. Later on, the whole plant collapses as though it has been cut. The tubers are also affected; and when cut, they show the characteristic brown ring from which the disease gets the name of ring disease.

In order to control this disease, one should not obtain seed from areas in which it occurs. If the cut pieces are used for sowing, the whole lot should be discarded if they show signs of this disease.

When the disease has occurred in any field it is advisable to use a long rotation from which such related plants as tobacco, tomatoes or brinjal should be eliminated.

*Minor diseases*—The potato crop in India is also subject to numerous diseases, which are more or less restricted to certain localities. Their damage to the crop

as far as is known at present is not of very great economic importance. Some of these are the following:—

1. *Early blight (Alternaria solani)*—This has been found to occur in the Indo-Gangetic plain and in the Nilgiris in South India. The disease is distinguished from other types of potato disease by the pale brown spots on the leaves, surrounded by concentric narrow darker rings.

2. *Rhizoctonia* sp.—There are numerous forms of this organism, but three are known to occur in India and to attack potatoes. This may cause both root rot and tuber rot. Most of the injury is due to lesions on the underground part of the stem. This disease has been found to occur in the district of Poona in the Bombay Presidency, and in Bihar.

3. *Leaf blotch (Cercospora concors)*—This disease is commonly found in Bengal, Bihar and the Bombay Presidency, and is sometimes mistaken for the leaf blight. The disease at first appears on the leaves as small green roundish spots which later change to yellow and finally to brown.

4. *Virus diseases*—Potatoes are also subject to certain diseases for which the causal organisms are unknown, but are believed to be some forms of viruses. The attack of the viruses on the potato plants causes certain characteristic symptoms which are known as mosaic, leaf roll, crinkle, rolled edge, spindle tuber, curly dwarf, etc. Probably the most common of these are the mosaic and the leaf roll. The mosaic diseases in general cause the mottling of the leaves and their wrinkling and ruffling, as well as the dwarfing of the whole plant. Leaf roll is the rolling upwards of the leaves parallel to the midrib. The leaves also are stiff and erect with tints of pink and yellow.

The common method of combating with diseases of this type is the careful roguing of all diseased plants. Persons handling such diseased plants should be careful not to touch the healthy ones. Such persons should also carefully wash their hands in a disinfectant.

*Insect pests*—The most common insect pest attack-

ing the potato crop in this country is the green bug (*Nezara viridula*). The insect occurs all over India, including the hilly regions. The adult is a shield-shaped insect about five-eighths of an inch in length, of a uniform light-green colour, with a yellowish portion on the head.

The damage to the potato crop is done by both nymphal and adult bugs, which feed on the host plants by sucking the sap from them. The insect is also known to attack wheat, *bajra*, *jowar*, *ragi*, tomatoes and beans.

No satisfactory control measures for this insect have been developed. The use of pyrethrum dust, or pyrethrum dust mixed with an equal quantity of 2½ per cent nicotine dust, will only act as a deterrent, as the adult bug is very extremely difficult to kill.

Where the insect is common, clean cultivation and a long rotation from which its common food plants are to be excluded, has been recommended for the control of this insect.

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## CHAPTER IX

### LINSEED

*Origin and history*—Linseed (*Linum usitatissimum*) more commonly known in western countries as flax, is grown in this country mainly for the oil which the seed contains, whereas in western countries it is grown more especially for the fibre which is obtained from the stem and used in the manufacture of linen goods. The plant belongs to the flax family or *Linaceae*.

According to Vavilov, the small-seeded types of linseed grown for fibre and for seed originated in south-western Asia, in a region of which Afghanistan is the centre. From there it spread northwards to Europe and other parts of Asia and south to India, the northern forms evolving into early races with long unbranched stems, whereas the southern forms are late and much branched.

India for a long time supplied the bulk of the world's need for linseed, but in recent years countries such as Argentina and the United States of America have also grown linseed in large quantities. According to the trade figures of 1933-34, the world's supply of linseed from the five leading linseed-producing countries was as follows:—

	Tons
Argentina .. .. .	1,414,000
India .. .. .	376,000
U. S. A. .. .. .	174,000
Uruguay .. .. .	72,000
Poland .. .. .	44,000

*Distribution in India*—In this country the main regions where this crop is grown are in the central parts



of the country, chiefly in Bihar, the Central Provinces, Central India, and parts of the United Provinces. It is also grown extensively in Hyderabad. But in general, the crop is grown in all the provinces of India except in the drier parts of Rajputana, and certain areas in the Madras Presidency. The following table shows the distribution of this crop according to provinces and States.

TABLE II  
Showing the Distribution of Linseed in India.

Provinces and States	Area in thousand acres in		Yield in thousand tons in	
	1937-38	1940-41	1937-38	1940-41
Bihar .. ..	587	534	87	71
C. P. and Berar .. ..	1,243	1,217	103	97
United Provinces .. ..	316	255	52	49
Hyderabad State .. ..	471	430*	41	37
Bengal .. ..	137	155	27	22
Bombay .. ..	107	112	9	10
Bhopal State.. ..	65	56*	7	6
Punjab .. ..	30	33	3	2
Others .. ..	883	806	103*	102*

*Botanical description*—Linseed is a herbaceous annual growing to a height of from 1 to 4 feet. The Indian linseed is usually shorter, reaching about  $2\frac{1}{2}$  feet in height. But linseed in other countries, as it is generally grown for fibre, is very much taller. The Indian linseed is also branched, as this is the character which is desirable for seed production. The linseed of other countries usually consists of a single main stem with few lateral branches which develop towards the upper part of the stem. According to Howard and Rahman, who have divided the linseeds of India into two main groups, the peninsular or South India types and the alluvium types of Northern India,

\* Approximately.

the former are less branched than the latter.

The leaves of the linseed plant are small, narrow and blunt at the apex. Of the two Indian types, the peninsular type sheds its early leaves.

The inflorescence consists of a terminal panicle which bears numerous flowers. The flowers vary in colour, and are usually either white or blue.

The plant is normally self-pollinated but insects visit the flowers which contain nectar glands, so that natural cross-pollination is not impossible.

The fruit is a capsule which is commonly known as the "seed ball." These capsules are divided into five locules or compartments in which the seeds are borne. The seeds are quite small and flattened, and vary in colour from white to dark brown. The oil content of the seeds is usually about 35 per cent. The seed of the varieties from other countries usually has a lower percentage of oil than the Indian linseed. In India also the oil content of the alluvium type is lower than that of the peninsular type. Some of the Indian linseeds now possess an oil content of about 47 per cent. It is generally believed that the white-seeded ones produce more oil than the brown ones.

The root system is usually shallow and abundant. The main tap root is slender and possesses small lateral roots which develop in the first 1 to 1½ feet of soil. Again, the two types of linseed in this country possess different types of root systems. The peninsular type is usually more deep-rooted, and the branching does not occur until the tap root has penetrated to a considerable distance. The alluvium type is shallow-rooted with lateral branches developing at once near the surface of the soil. It has been found that the deep-rooted types of the Peninsula produce larger seeds with a higher oil content than the alluvium types..

*Ecological factors*—From the fact that linseed is grown in this country and can be grown also in other parts of the world up to 62°N. latitude, it may be said in general, that the plant can stand different types of climate. However, in this country linseed is grown in many parts

of India as a cold season (*rabi*) crop. Some Russian investigators believe that the production of linseed with high oil content requires much light and warmth and less moisture. When grown for fibre, the best results are believed to be obtained in cool, moist climates. In general it may be said that linseed can be grown successfully wherever wheat is grown.

Linseed can also be grown in almost all types of soil, where sufficient moisture is available, but it will do best on the heavier soils which are more retentive of moisture. The peninsular type is mainly grown in the black cotton soil, to which it is especially adapted due to its deep rooting habit, quick growth and early maturity, which are all desirable characters on account of the cracking of the soil and the consequent rapid loss of moisture. The alluvium type which is shallow-rooted, slow-growing and late-ripening is more adapted to the alluvial soils of the Indo-Gangetic plain where more moisture is usually available. This type is therefore grown in the Indo-Gangetic alluvium of Northern India.

*Classification*—The Indian linseeds have been classified by Howard and Abdur Rahman (1922-1924) into 26 varieties which include 123 different types. The main grouping of these different varieties is according to the colour of the seeds, that is, whether yellow, white, fawn-coloured or brown. The three divisions are then subdivided according to the colour of the corolla, that is, whether white, light blue, blue or purple. The finer subdivisions are according to the colour of the anthers, then of the filaments and the style, and finally according to the size of the seed, that is, whether bold (large), medium or small.

*Seed-bed preparation and planting*—The land where linseed is to be grown is prepared in almost the same way as wheat lands are prepared. The object in the preparation of the land for sowing is to secure a fine, firm and porous seed bed. This is accomplished by ploughing the land several times, followed by harrowing or the re-

removal of all weeds and trash. The land is then rolled or planked by means of a planker or *patela*. When the land is ready for sowing, the seeds are sown usually by means of a drill or by dropping seeds through a tube attached to a *desi* plough. The seeds are also sometimes sown by broadcasting. In certain localities it is sown as a mixed crop with gram or with *rai* (*Brassica juncea*). When sown alone and in lines, the distance between two lines is about a foot. The amount of seed sown in this way varies from about 8 to 12 lbs. per acre.

The crop usually requires no care after sowing, except that when planted late it may require irrigation. No weeding is necessary if the land has been well prepared before the seed is sown. In most parts of India sowing is done in the middle of October, when wheat and other *rabi* crops are sown. The varieties of linseed that have been recommended by the Pusa Research Institute are Types No. 12, No. 121, and No. 124. More recently new hybrids have been produced and several of these appear to be promising.

In Central India several selections have been made, out of which the following have been found to be promising : E. B. 3, with an oil content of 49.32 per cent and Dhar white, with an oil content of 47.15 per cent.

In the United Provinces, work with linseed is being carried on and several strains have been evolved which are now under trial in different parts of the province. Of these E. B. 1150 seems to be one of the promising strains for the province.

In the Central Provinces, E. B. 3, a promising variety, has been crossed with certain rust-resistant varieties from Pusa and imported varieties of flax. The results of these crosses are now under trial.

*Harvesting*.—The crop is usually ready for harvesting about the beginning of March. When the crop is ripe, it is cut with sickles and then taken to the threshing floor where the seeds are beaten out and winnowed. The seeds are then ready for marketing.

*Diseases and pests*—The linseed crop in most parts of this country may be said to be almost free from serious diseases or insect pests. The most injurious of the fungous diseases attacking this crop is probably rust (*Melampsora lini.*) This disease attacks both the leaves and the stems of the plant. The leaves and stems of the affected plants are covered with bright orange-coloured pustules, which later may turn brown or black. The disease is probably transmitted through fragments of branches or leaves of the previous crop included amongst incompletely cleaned seed. Direct control measures for the disease are not practicable.

The other disease which is found in linseed but which is less common in this country is known as flax wilt (*Fusarium lini.*) This disease attacks plants at all stages of their growth. The affected plants simply dry up and die. The roots of such affected plants when examined will be found to show a characteristic ashy appearance. The disease is disseminated through the seed. The disease therefore may be controlled to some extent by seed treatment. This may be done by moistening the seeds in a mixture of a pound of formalin with forty gallons of water. This quantity of the solution is sufficient to treat about 50 maunds of seed.

Another disease which has been reported on the linseed crop is an *alternaria* blight, but it seems that this disease occurs only in some restricted areas in the United Provinces.

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CHAPTER X

GRAM

*Origin and history*—Gram (*Cicer arietinum*) is probably one of the most common of the pulses in this country. It is used for human consumption as well as for feeding to animals. This pulse has been known in this country for a long time. Its origin was probably in south-western Asia, that is, in the countries lying to the north-west of India, such as Afghanistan and Persia. According to De Candolle, the fact that gram has a Sanskrit name would indicate that the crop has been under cultivation in this country longer than in any other country.

*Distribution in India*—This crop is grown mostly in the Punjab, the United Provinces, Bihar, the Central Provinces and Berar and Hyderabad State, although it is grown to some extent in almost all parts of India. The following table shows the distribution of gram in India and the total yield from each of the provinces and States mentioned.

TABLE 12  
Showing the Distribution of Gram in India.

Provinces and States	Area in thousand acres in		Yield in thousand tons in	
	1937-38	1940-41	1937-38	1940-41
United Provinces ..	5,757	5,105	1,643	1,460
Punjab .. ..	3,755	3,450	640	663
Bihar .. ..	1,366	1,444	453	485
C. P. and Berar ..	1,191	1,152	222	230
Hyderabad State ..	1,255	1,253	198	209
Bombay .. ..	674	585	95	83
Mysore .. ..	785	835	85	78
Bengal .. ..	279	319	72	94
Sindh .. ..	363	389	61	59
N.-W. F. Provinces..	142	138	26	21
Madras .. ..	52	66	10	12
Delhi .. ..	56	22	16	5

*Botanical description*—This plant belongs to the family of legumes (*Leguminosae*). It is a much-branched annual attaining a height of about 2 feet or more. The plants may be either erect or of a spreading type. A group of grams known as Kabuli grams are generally taller than the local Indian crop, and stand more or less erect. The main branches usually produce not more than one secondary shoot, but in some types the main branches may produce numerous lateral branches.

The leaves are pinnately compound, usually with one terminal leaflet. The number as well as the size of the leaflets, however, varies in different types. The colour of the leaves also varies in the intensity of the green colour, some being light green while others are green or dark green. Certain types also possess leaflets with red margins.

The flowers are papilionaceous, and possess various colours which vary from white or greenish to various shades of pink or blue. The flowers are usually solitary and are developed at a node opposite to the leaf. The pods usually contain two seeds. However, one or three seeds per pod often occur. The flowers in gram are normally self-pollinated, but nevertheless natural crossing occurs occasionally.

The seeds vary in size as well as in colour. The seeds of certain types are whitish, while others are either yellowish, brown or reddish. The intensity of colour of the seeds in any one plant may vary, due to an imperfect development of the colour on account of unfavourable weather conditions during the ripening of the grain.

Gram has a well-developed root system. The roots usually include a central tap root with numerous lateral branches which spread out in all directions.

*Ecological factors*—Gram is a cool season crop in this country. Like wheat and linseed, in Northern India it is sown about the middle of October after the rains are over.

Gram is fairly sensitive to the conditions of the wea-



ther during flowering time. Frost during this period will result in the failure of the flowers to develop seeds or in the killing of the seeds inside the pod. Heavy showers are also detrimental to this crop, as too much moisture in the soil is not favourable for its development.

The best type of soil for gram is one which is well drained and not too heavy. Some of the heavier soils which are good for wheat are not very suitable for gram, as high fertility in the soil stimulates excessive vegetative growth at the expense of seed production. Consequently in most parts of the country gram is grown in fairly light soils, mostly loams, which are too poor for wheat.

*Classification*—The Indian grams have been classified by the Howards and Khan, and later by Shaw and Khan. The Howards and Khan classified the grams obtained from several parts of the United Provinces and Bihar into 25 different types. Their classification was mainly based on the size of the plants, leaves, flowers and seeds. Further sub-divisions were based on the colour of the corolla, that is, whether white, blue, pink, or greenish. Finer sub-divisions were based on the following characters : (1) the presence or absence of hairs on the standard and wings, (2) the dropping off or persistence of the standard, (3) the earliness of maturity, (4) the colour of the seeds, (5) the habit of the plants, that is, whether erect or spreading, and (6) the colour of the leaves.

More recently Shaw and Khan made a further study of the Indian grams which were collected from all over India and added 59 types to the 25 types previously classified, thus giving 84 types altogether. According to their classification, type No. 1 is separated out from other types on the basis of the persistent character of the standard. The other 83 types were then further classified on the colour of the flowers, that is, whether blue, white or pink. Of these types, type No. 13 is the only one possessing blue flowers. The other characters used for further classification of the types are the size of seeds, colour of grain, shape of grain, character of the seed surface (that is, whe-

ther puckered or smooth), the size of pods (that is, whether large, medium or small), earliness, colour of the leaves, number of flowers on the peduncle, etc. References to these classifications are given at the end of this chapter.

*Cultural methods*—The land where gram is to be sown usually does not require as good preparation as in the case of wheat. Generally one or two ploughings are given, and ordinarily the seed bed is not pulverized. The crop is usually grown on land which has been left fallow during the *kharif* season, but sometimes it is also grown on the land where an early fodder crop such as *jowar* has been grown in the *kharif* season. This is usually sown earlier than any other *rabi* crop. The sowing is usually done about the beginning of October in most parts of Northern India. The seeds are usually sown by dropping them through a tube attached to a *desi* plough. The amount of seed varies from about 15 seers in the Punjab to 20 in the Central Provinces. Certain varieties of gram such as the *Kabuli* gram have been found to do better with a higher seed-rate. The crop does not require any care after sowing. It is believed by most cultivators that nipping off the tips of the shoots just before flowering encourages more branching and thereby increases the yield. The crop is usually not irrigated. Even heavy rains during the period of its growth may sometimes damage the crop.

When the leaves of the crop begin to turn yellow and the plants begin to dry up, the crop is ready for harvesting. This is done by cutting the plants with a sickle and they are then taken to the threshing floor. The cut plants are allowed to dry for a few days, and are then threshed by having the bullocks tread on them as in the case of wheat. The chaff (*bhusa*) is separated from the grain by winnowing.

*Diseases*—The gram crop in this country is subject to the attack of two diseases which are called blight and rust. The former is commonly found in the North-west Frontier Provinces and in the Punjab, whereas the latter

occurs in the more humid regions of the country, such as Bengal, Bihar, Bombay and Madras.

*Blight* (*Ascochyta Rabiei* (Pass), Lab—*Phyllosticta Rabiei* (Pass), Trot) has been found to cause serious damage to the crop in the North-west Frontier Province and in the northern Punjab. The disease is caused by a fungus and appears as brown or dark spots on the leaves, stem and pods. The spots vary in size and are usually circular on the lamina and pods, but elongated on the stems and petioles. These spots generally encircle the stem completely, causing the plant to droop and die. The disease is seed-borne, and is also carried on the plant parts which compose the *bhusa*, and in other crop residues. The disease may therefore be controlled by the use of disease-free seeds and the elimination of all crop residues by harvesting the crop by pulling up the plants. The disease may also be controlled by ploughing under all crop residues at the beginning of the monsoon rains, while all debris from the threshing floor should be burnt. The *bhusa* also should not be allowed to get to the fields. Mixed cropping with wheat or barley is also believed to help in checking the spread of the disease.

Rust (*Uromyces Ciciris-arietini*) in gram occurs in Bengal, Bihar, Madras and Bombay. The disease is caused by a fungus which chiefly attacks the leaves. The disease occurs as small rusty-brown pustules on both surfaces of the leaves, but more frequently on their lower surfaces.

No practical method of controlling this disease is now known.

Besides the above two diseases, gram is also subject to wilt. This causes a uniform wilting of the plants. The disease is believed to be due to physiological conditions or to a fungus known as *Rhizoctonia baticola*. Dastur, working in the Central Provinces, believes that more damage is caused to the gram crop by the physiological wilt than that caused by *Rhizoctonia baticola*.

*Insect pests*—One of the commonest insect pests which attack the gram crop in this country is known as

the gram caterpillar (*Chloridea obsoleta*). The adult of this insect is a moth, but most of the damage is done by the caterpillar. This caterpillar, which is about an inch long, is usually greenish but with tints of various colours. It feeds on the leaves as well as pods, but later on it attacks the seed by biting through the pod. However, it does not go inside the pod but feeds on the seeds from outside it. The insect is known to attack several crops. No control measures for this insect have been devised.

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## CHAPTER XI

# GROUNDNUTS

*Origin and History*—The groundnut or peanut is one of the most common oilseed and food crops of this country. Its cultivation and total production is greater in India than in any other country of the world. But the plant has only recently been introduced into this country. Its native home, according to the consensus of opinion of most investigators, is Brazil in South America. It is believed to have been taken into other countries by the Portuguese. It was probably introduced from the Phillipines into South India, whence the name *Manila-kotai*, or from China into Bengal where it is known as *Chinabadam*, or from Africa, or even direct from Brazil into western India. Or it may have been introduced independently from each of these countries: Its cultivation in this country on a field scale, however, seems to have begun about the year 1800, in South India. Since then its cultivation has been spreading very rapidly, especially in the black cotton soil areas where it is being used as a rotation crop for cotton.

The other countries which compete with India in the supply of groundnuts to the world's market are French West Africa, the United States of America and the Dutch East Indies.

The world's production of groundnuts at present is estimated at about 5 million tons a year, of which India contributes about 3 million tons. About 40 per cent of groundnuts in world trade are from India.

*Distribution in India*—Although the crop is now commonly grown in most parts of the country, yet most

of the groundnuts are produced in the Presidencies of Madras and Bombay and in Hyderabad State.

During the five years ending 1933-34 the Madras Presidency alone had 48.2 per cent of the total area under groundnuts in India.

The following table shows the distribution of this crop in India according to provinces and States.

TABLE 13  
Showing the Distribution of Groundnuts in India

Provinces and States	Area in thousand acres in		Yield of unshelled nuts in thousand tons in	
	1937-38	1940-41	1937-38	1940-41
Madras .. ..	4,658	3,922	2,059	1,924
Bombay .. ..	1,214	1,580	462	663
Hyderabad .. ..	1,438	1,200	476	355
Bombay States .. ..	1,022	838	347	255
C. P. and Berar .. ..	215	233	55	65
Mysore .. ..	198	181	37	32
Punjab .. ..	..	37	..	..
Orissa .. ..	..	24	..	7

*Botanical Description*—The groundnut (*Arachis hypogaea*) is a member of the pulse family (*Leguminosae*.) It is a herbaceous annual with a more or less upright central stem, and with numerous branches which may vary from prostrate to almost erect, depending on the variety. The central stem is usually taller in the erect types. The branches may vary in length from about  $1\frac{1}{2}$  to 2 feet.

The leaves are pinnately compound and are composed of two pairs of oval leaflets.

The flowers are borne at the axils of the leaves, either above or below the ground. Sometimes when a portion of a branch is covered with soil, flowers may form and bloom, and the fruit may develop without appearing above the soil. It was formerly generally believed that the flowers are of two kinds, fertile and infertile, but it is now generally agreed

that they are of one kind and are always perfect. The corolla is orange yellow in colour and is placed at the end of a long slender tube which is the calyx crowned with five calyx tips. After fertilization the ovary stalk elongates, bends over, pushes the minute ovary into the soil where the pod begins to develop, and increases in size. It is very essential that the ovary be able to push itself into the soil, as otherwise fruit formation does not take place.

Ordinarily groundnut flowers are self-pollinated, but cross-fertilization may take place due to the visitation of the flowers by insects.

The fruit is an oblong, more or less constricted pod of pale straw colour, which varies in size according to the variety. The pod contains one to several ovoid seeds. The shell of the pod which contains the seed is morphologically the pericarp and the thin skin which covers the seed or nut is the seed coat or testa. The testa varies in colour in different varieties. It may be brick red, russet or light tan. The nut is composed of two cotyledons. It is these structures which contain the oil and other food materials.

The root system in the groundnut plant is not well developed. It consists mainly of a tap root and a few lateral branches.

*Ecological factors*—The groundnut is essentially a tropical plant and therefore requires a long and warm growing season. While the plant requires a certain amount of moisture, an excess of water is detrimental to its growth. In this country it is usually grown in regions where the amount of rainfall is from 20 to 35 inches annually. During its ripening period it is essential that there should be about a month of warm dry weather. It seems that the plant will grow best where the mean temperature is from 70° to 80°F. Lower temperatures are not suitable for its development, and frost is very detrimental to this crop.

The type of soils most suitable for this crop are light soils, well manured and rich in organic matter. In this country most of the groundnut crop is grown in the

black cotton soils of the Madras and Bombay Presidencies and the red soils of the Deccan. But the crop also does well in the alluvial soils of the Indo-Gangetic plain.

*Classification*—The cultivated groundnuts have usually been divided into two classes, the erect and the trailing types. The erect types were called by Waldron *Arachis hypogea* sub-species *fastigiata*, and the trailing or running types, sub-species *procumbens*. He is of the opinion that these two have independent origins, the erect type having originated from *Arachis pusilla* and the trailing type from *Arachis prostrata*. It is reported, however, that the two types have been crossed frequently and hybrids produced which do not show any evidence to indicate that they are species hybrids.

The varieties of groundnut cultivated in India seem to fall into four main groups as follows:—

1. *Mauritius groundnuts*: These are also sometimes known as Mozambique, Pondichery or Coromandel Machine shelled.

2. *Bombay Bold*: These consist mainly of the Big or Large Japan and the American Virginia variety.

3. *The Spanish Groundnut*: These are sometimes known as Natal nuts or Khandesh nuts when they come from that area.

4. *The Small Japan groundnuts*: These are known locally by different names such as Lal Boria, Red Ponani or Red Natal.

A general key to the varieties of groundnuts cultivated in India.

- A. Habit trailing or running; pods produced along branches, some distance from the base; late maturing.....  
.....subspecies *procumbens*.
- B. Branches prostrate, pods medium size; constrictions of pods not pronounced.....Mauritius varieties.
- BB. Branches spreading laterally but some, half erect; pods very large; constrictions of pods well-pronounced.....Bombay Bold varieties.



- AA. Habit erect; pods clustered near the base; early maturing.....sub-species *fastigiata*
- B. Constrictions of pods well-pronounced; seeds small, more or less round, of a light rose colour when fresh, darkening with age. .Khandesh (Spanish) varieties.
- BB. Constrictions not so pronounced; seeds more or less round, blood red or dark red.....  
.....Small Japan varieties.

*Cultural methods*—Groundnuts are generally grown as a *kharif* crop. The land should be thoroughly ploughed. The first ploughing may preferably be done immediately after the *rabi* harvest. In several parts of Madras the crop is also sown during the *rabi* season. In such cases groundnuts may follow groundnuts, in which case the number of ploughings will be less for the second crop, since some ploughing would have been done in connection with the harvesting of the previous crop. The land should be worked until it is fairly well pulverized.

The method of planting groundnuts varies in different regions. In certain areas the seed is drilled, while in some others the seed is dropped in the furrow opened by the plough. The seeds when dropped in the furrow are covered by means of a planker (*pathar* or *patela*). The covering of the seed is very necessary, as otherwise they may be picked up by birds, jackals or other animals. When planted in lines the distance between lines is about one foot, and the distance from plant to plant in the lines varies from 4 to 9 inches. In several parts of Madras, the groundnut is sown mixed with such crops as *bajra* or *cumbu*, sesamum, and *ragi*. In such cases it is sown at the time of the first hoeing of the sown crop by hoeing in the seeds of the groundnuts. The amount of seed sown per acre varies with the locality as well as the variety sown. Mauritius varieties in Madras are usually sown at the rate of 30 to 40 lbs. per acre, whereas the bunch types require about 80 lbs. of seed per acre.

The seeds are generally sown after they have been shelled, but sometimes unshelled pods containing only

one seed per pod are selected for sowing. In some cases such one-seeded pods are cracked and sown without removing the shell. It is, however, always advisable to sow shelled nuts as this allows one to judge their quality better.

In the Madras Presidency the common varieties of groundnut sown are Mauritius, a trailing type, and *Gudiyattam* (Spanish), a bunch type.

In the Bombay Presidency and the Central Provinces the varieties generally grown are Bombay Bold, the Spanish or Khandesh types and small Japan. The Akola varieties of the Central Provinces are gaining in popularity in the province. Of these, Akola 10 and Akola 12-24 are the most promising and have been found to do well outside that province.

Apart from yield, further improvement of these varieties should aim at a higher oil content, and the production of a strain in which all the pods should ripen at about the same time.

When groundnuts are sown in lines they are usually cultivated by means of a bullock-drawn hoe (*daura*) until the plants develop the gynophores or "pegs" in which the pods are borne. This stage is indicated by the production of flowers. If a later weeding is necessary, and this should not be done ordinarily, it should be done by pulling the weeds carefully by hand. At this stage there is always a danger of damaging the developing pods in the soil. When groundnuts are sown as a mixed crop, usually all the weeding is done by hand or by hoeing.

In the Madras and Bombay Presidencies the groundnut is to some extent grown as an irrigated crop. In that case furrows are made between the lines and the water is made to run down these furrows.

Groundnuts, being a leguminous crop, usually do not require any manure, but in Madras where they are grown from year to year in the same field, the applications of a potash fertilizer may be necessary. Experiments in the Central Provinces seem to show that an application

of sulphate of potash is profitable for groundnuts. In some soils an application of lime has also proved beneficial to the crop.

Groundnuts should be harvested when fully ripe. If harvested before this stage there is a high percentage of fatty acid which has not been converted into oil. It has been found that the harvesting of groundnuts even one week before the nuts are fully ripe decreases the oil content by about five per cent.

The maturity of the crop is usually indicated by the yellowing and shedding of the lower leaves. Ripe pods may be distinguished by their darker colour and comparative dryness. However, all the pods in the plant do not mature at the same time. Nevertheless the crop is usually harvested at one time.

Harvesting is done in several ways depending on the locality and character of the soil. In the lighter soils the plants are usually pulled up by hand, and practically all the pods come out with the plant. But in heavy soils such as the black cotton soil, the tops are usually cut off by sickles and the pods are brought to the surface by ploughing. The pods are then usually picked up and dried. The leaves and stalks are usually fed to cattle.

A heavy rain during the harvesting period is usually very detrimental to the crop.

*Diseases*—Of the diseases which attack this crop in this country, perhaps only one is of economic importance. This is commonly known as the *tikka* disease, and is caused by a fungus (*Cercospora personata* (B. and C.), Ellis, or *Septogloeum Arachidis*, Rac). The disease usually appears on the leaves in the form of small dark-brown spots. These spots increase in size and may coalesce with one another. The leaves then turn yellow and fall to the ground. If the disease is serious the plants are not able to mature their nuts. This disease causes the nuts to shrivel and lie loose in the shell.

The disease cannot be controlled by spraying, as the fungus usually lives on the undersurface of the leaf,

and consequently cannot be reached by spraying. The disease has been controlled by introduction of foreign varieties which have proved immune to it.

Where the seed comes from an infected area it may be disinfected with a formalin solution (1 lb. of formalin in 40 gallons of water), as a precautionary measure.

Another disease which sporadically occurs in certain areas is known as root rot and is caused by a fungus (*Rhizoctonia destruens*), which is also responsible for the root rot of potatoes.

*Pests*—Groundnuts are subject to attacks of various pests, but the damage done by any one of them is slight and varies somewhat in different localities. Among the insect pests attacking the crop the hairy caterpillar (*Antigastracatalaunalis*) may be mentioned.

The crop is, however, also subject to damage by white ants, jackals, wild pigs and birds. Watching and the use of scare-crows are the only remedies used in this country for these pests.

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## CHAPTER XII

### ARHAR AND TUR

*Origin and History*—Botanists are not definitely of one opinion regarding the place of origin of the pigeon pea (*arhar and tur*). Some botanists are of the opinion that India is the place of its origin. The majority, however, favour Africa in the upper regions of the river Nile. As the plant has been found wild in those parts of Africa, it seems that Africa is the more probable place of origin. The plant therefore might have been introduced into this country by the early traders who carried on trade between India and Africa. The plant has now been cultivated in this country for more than three thousand years. It is now one of the most widely cultivated pulses in India. At present it is grown in almost all the tropical countries of the world as a cultivated crop, including Africa, America, Australia, Hawaii, the West Indies and in the East Indies.

*Distribution*—In this country the pigeon pea is usually grown as a mixed crop with *jowar*, *bajra*, cotton and many other crops. Statistics of the areas devoted to this crop are therefore difficult to obtain. It is, however, mainly grown in Bihar, the Central Provinces, Bengal, the United Provinces, Bombay, Madras and Assam.

*Botanical description*—The pigeon pea (*Cajanus indicus*, Spreng) is, like all pulses, a member of the family of legumes (*Leguminosae*). Two varieties of this crop are generally recognized. The late-maturing variety generally grown in Bihar, Bengal, the United Provinces and Assam and known as *arhar* is *Cajanus indicus* var. *bicolor*. The early-maturing variety generally grown in the Central Provinces, Bombay and in Central India and known as *tur* or *tuar* is *Cajanus indicus* var. *flavus*. The plant is an erect

shrub, and a perennial; but in this country it is always cultivated as an annual, as the yield of the second year's crop is too low to make it profitable as a ratoon crop. The height as well as the circumference of the plant depends on the fertility of the soil and the amount of space given to it. In good soils and a good amount of space the plant may grow to a height of 6 to 7 feet. The plant is much-branched. The branches may vary from erect to spreading, depending on the angle which the branches make with the main stem. This habit varies with the varieties. The branches are grey-silky in colour, and feel.

The leaves are trifoliate. The leaflets are entire and densely-silky on the lower surface. The intensity of the green colour of the leaves varies with the varieties. The total length of the leaf and the size and shape of the leaflets also vary with the varieties.

The inflorescence is an axillary raceme often forming a terminal panicle. The flowers are distinctly papilionaceous. In the late varieties the flowers are usually grouped together at the end of the branches, but in the early varieties the flowers are produced at several points along the branches. The crop is characterized by the great extent of its flowering period, the process of flowering continuing in each plant up to the time of the harvest. The flowers are self-pollinated, pollination taking place before the flowers open. Cross-fertilization, however, occurs freely due to the visitation of the flowers by insects. The amount of cross-fertilization at Pusa (Bihar) has been found to vary from 0.15 to 7.59 per cent.

The crop is also characterized by the great number of flowers which it produces, but a considerable number fall off without setting, this shedding being greatly influenced by the weather conditions during the time of flowering. Damp and cloudy weather encourages shedding, whereas bright sunny days reduce it considerably.

The fruit of the pigeon pea is a pod which is usually constricted obliquely between seeds. When the pods are constricted they are termed "beaded", and when not

so constricted they are termed "not beaded." The pods vary in colour from green to dark. The intermediate forms are usually green with dark maroon blotches. The seeds within the pod vary in number, but there are usually four or five in each pod in the *arhar* (late varieties), and only two or three in the *tur* (early varieties). They also vary a great deal in colour, the majority being either brown or white, but they may be also chestnut brown, purplish black, or dark-mottled brown.

The root system of the pigeon pea consists of a central tap root with numerous laterals and secondary branches. The length of the lateral roots also varies with the varieties, being usually longer in the spreading types than in the erect ones.

One of the reasons why the pigeon pea is commonly used in this country as a renovating crop is its deep and penetrating roots which break up the subsoil, inducing a better physical condition.

*Ecological factors*.—The crop usually prefers a fairly moist climate during the period of its vegetative development. It is for that reason commonly sown with the *kharif* crops. During the flowering and ripening stages of its growth, it requires bright sunny weather which is favourable for the setting of fruit. One of the main characters which limits its growth in the northern parts of India is its inability to withstand frost.

The crop may be grown in almost all types of soils, but it prefers a light moist soil in which its roots can develop freely. It is grown in the black cotton soil of the Central Provinces, Central India and the Bombay Presidency as well as in the alluvial soil of the Indo-Gangetic plain. When sown as a mixed crop it is usually sown in such soils as suit the other crop with which it is associated.

*Classification*.—The pigeon peas of India naturally fall, as mentioned above, into two groups: the *arhars* (*Cajanus indicus* var. *bicolor*) and *turs* (*Cajanus indicus* var. *flavus*).

The *arhars* are late-maturing varieties. The standard,



which is the largest of the five petals in the flower, possesses red veins on the dorsal side. The plants of this group are also taller than those in the other group. The pods in *arbar* also usually contain from four to five seeds.

The *turs* or *tuars* are early-maturing varieties. The standard is wholly yellow and possesses no red veins. The plants of this group are usually shorter; the pods also usually contain two or three seeds.

The pigeon peas of the Central Provinces have been classified into 36 different types. More recently (1933) Shaw, Khan and Singh have classified the pigeon peas which they collected from all over the country, into 86 different types.

*Cultural Methods*—The land where the pigeon pea is sown, when sown mixed with other crops, is the same as that for the crop sown with it. For instance when sown with *jowar* the land is prepared more especially to suit the proper germination of the *jowar* crop rather than that of the pigeon pea. In the same way when it is sown with cotton, the preparation of the land is for that crop. When it is grown in lighter soils with *bajra*, the land does not require any more preparation than what is needed for the *bajra* crop.

When the pigeon pea is sown as a mixed crop, the usual custom is to sow three or four lines of the other crop between two lines of pigeon peas. When sown alone, the distance between the rows varies with different localities and with the varieties. *Tur* in the Central Provinces as well as in Central India is sown at a distance of about 14 to 16 inches apart between the rows. In the Indo-Gangetic plain such as in Bihar and the United Provinces, the distance for *arbar* may vary from  $1\frac{1}{2}$  to 2 feet between the rows. When sown in lines the usual method is to drop the seeds through the tube attached to the *desi* plough.

When the pigeon pea is sown alone the seeds are usually broadcast.

The amount of seed used per acre when sown mixed with other crops is usually about 4 to 5 lbs. per acre, but

when sown alone the amount of seed for the late maturing varieties (*arhar*) is about 12 to 15 lbs. while for the early types it is about 20 lbs.

Pigeon pea usually does not need any irrigation, but sometimes watering is given in order to protect the crop from damage by frost. The crop also does not need any weeding when sown alone, but when sown mixed with other crops, the weeds which infest the other crop are sometimes removed, as is done when it is sown mixed with cotton.

When the plants are ripe, the stalks are cut as near the ground as possible by means of sickles. They are then tied in bundles and taken to the threshing floor and allowed to dry for a few days. The leaves and pods are then stripped off from the stems and heaped up in a pile. These are usually threshed by having bullocks treading on them. The other materials are separated from the grain by winnowing. The leaves and broken pods are fed to cattle while the stalks are used for roofing, basket-making, etc.

*Diseases and pests*—The most common disease which attacks the pigeon pea is known as wilt (*Fusarium udum*, Butl.) The disease is caused by a fungus which interferes with the upward movement of the water in the plant causing it to wither and wilt. Occasionally the disease attacks the roots, stems and branches on one side of the plant only. The disease can be easily recognized by stripping off the bark which shows up the blackened stems clearly. In the early stages black streaks which may extend for some distance up the stem are seen. These, when traced down to the roots, will be found to have arisen from the main or lateral roots which have become rotten. Wilted plants usually occur in the field in patches. The wilting, however, usually appears when the plants are full-grown. The disease seems to be more common in the Indo-Gangetic alluvium.

No practical methods of controlling this disease directly can be recommended as the disease lives in the soil. The only method of control that is possible with

such diseases is the selection of resistant varieties. Such wilt resistant varieties of pigeon peas have been evolved at Pusa, of which Type 51 and Type 80 are considered to be fairly resistant. The former is an erect type, whereas the latter is spreading.

Another fungus disease which has been reported to attack the pigeon pea is known as the leaf spot disease of pigeon peas (*Cercospora indica*, N. Sp.). It has been found to attack this crop in Bihar and the United Provinces, where some damage is done by the disease.

The pigeon pea is also subject to attacks of various insects, the most common of which are probably the pod caterpillar (*Exelasta parasita*), the pod fly (*Muscidae acalyptrata*) and the leaf caterpillar (*Eucelid crittica*). The first attacks the pod, eating the seeds one after another from outside the pod; the second is a fly but the damage is done by the larva known as the maggot which feeds upon the seed; and the third is an insect which attacks usually the upper leaves of the plant by webbing them together.

No measures have been devised for the control of these insects, as the damage is not great.

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## CHAPTER XIII

### BARLEY

*Origin and history*—Barley is one of the most ancient of cultivated plants. There are abundant proofs that the crop was known to the Chinese, the Egyptians, and the lake dwellers in Switzerland in very remote times. The crop must also have been known in this country when the Aryans first came. The Sanskrit name *yava* (*yavaka*), which originally meant a grain, and was later limited to barley, and from which the name *jau* or *jau* has been derived, shows that barley was in those very early days regarded as one of the most important grains.

Evidence seems to show that the different forms of barley must have originated somewhere in the countries extending from the north-west of India to Abyssinia. It is very probable that the centre of origin is Asia Minor and Afghanistan, whence these different forms found their way through Syria and Palestine to Arabia and Abyssinia, while others spread to India.

It is to-day one of the most important cereals of the world, and is cultivated in almost all parts of the world except the tropical regions. The leading countries in order of production are Germany, the United States of America, India, Spain, Roumania, Japan, Canada and France. India is therefore one of the most important barley-producing countries of the world the total amount of production in 1934-1935 being 2,517,000 tons.

*Distribution in India*—In this country the bulk of the crop is mainly produced in the Indo-Gangetic alluvium, the areas of greatest production being the United Provinces, Bihar and the Punjab. The United Provinces alone produces approximately 66 per cent of India's total

production of barley. Its distribution according to provinces and States in this country is shown by the following table.

TABLE 14  
Showing the Distribution of Barley in India

Provinces and States	Area in thousand acres in		Yield in thousand tons in	
	1937-38	1940-41	1937-38	1940-41
United Provinces ..	3,755	3,859	1,301	1,488
Bihar .. ..	1,301	1,298	462	446
Punjab .. ..	777	800	206	219
N.-W. F. Province ..	179	159	55	42
Bengal .. ..	95	102	30	29
Ajmer-Merwara ..	52	48	16	20
Bombay .. ..	15	15	4	5
Hyderabad State ..	13	25	2	4
Sind .. ..	18	15	4	3
C. P. and Berar ..	15	12	3	2
Delhi .. ..	15	17	5	7

*Botanical character*—Barley belongs to the genus *Hordeum*, and like all cereals is a member of the grass family (*Gramineæ*). As a plant, it very much resembles wheat, but differs slightly from the latter in the length of the stems, the character of the leaves, and the structure of the spike. The stems possess from five to seven internodes. The height of the plants varies with environmental conditions and with the variety, but in general the average height is from two to three feet, which is shorter than wheat. The degree of tillering is usually as great as that in wheat. Lodging is not as common as in wheat. This latter character is probably due to the fact that in this country barley is usually grown in poor soils where wheat cannot grow well, and not to the inherent strength of the barley stems as compared with those of wheat.

The leaves of barley also resemble those of wheat but are usually broader, and the colour of the leaves is not

as deep green as that of the leaves of wheat, being usually light green. The leaves of barley possess very conspicuous auricles which are larger than those in wheat.

The inflorescence consists of a terminal spike, the shape of which varies slightly in different species, as for instance in what are called the two-rowed, the four-rowed and the six-rowed barleys. In barley three spikelets occur at a node on the rachis, a character which distinguishes it from wheat which possesses only one spikelet at a node on the rachis. In the six-rowed type, which is the most common in India, the spikelets are in six distinct rows and stand out equidistant from the rachis, all the spikelets being fertile and producing grain. However, whereas barley has only one floret in a spikelet, wheat usually contains three or more, and oats generally two or more. In the two-rowed barleys the spikes bear two longitudinal rows of grains. This is due to the fact that the outer spikelets at each node are infertile and only the central floret produces grain. In this way four rows are eliminated leaving only two. The four-rowed or common barley of western countries does not occur in this country.

Barley is normally self-pollinated, and natural cross-fertilization seldom occurs. The reason for this probably is that the styles are short and do not protrude beyond the glumes. Natural crossing does not occur in the two-rowed types. This is probably due to the fact that the flowers in the two-rowed barleys are known to open even before the ears emerge from the terminal leaf-sheath. The time required to head out for all the tillers in an individual plant depends largely on the variety, the vigour of the plant and the number of tillers per plant.

The grain of barley is a caryopsis, and, unlike wheat, usually adheres to the lemma and the palea or hull. In some varieties, however, which are known as naked barleys this condition does not occur. The grain in barley is usually larger and more uniform in the two-rowed than in the six-rowed types; but, the yield in the latter is usually greater.

The root system of barley consists of two, more or less, well-defined groups, the shallow and the deep roots. The shallow roots arise near the surface of the ground and spread out laterally almost at right angles to the tillers. The deep roots extend downwards into the deeper layers of the soil. In the shallow-rooted type of barley there is a greater development of the shallow roots, whereas in the deep-rooted types there is a greater proportion of the deeper-feeding roots. The shallow-rooted types of barley have been found to be more common in Bihar and other localities with abundant soil moisture, whereas the deep-rooted ones are found in the drier tracts, such as the United Provinces, Rajputana, the Punjab and Sind. It has also been found that the shallow-rooted types are earlier than the deep-rooted ones. The former are also erect or semi-erect while the latter, that is, the deep-rooted ones, have a tendency to be spreading or bushy.

*Ecological factors*—Barley is a plant that can grow fairly well in temperate as well as in sub-tropical regions of the earth. It does well in such countries as Germany and Ireland in the temperate regions, as well as in Arabia and India in the hotter sections of the globe. It is therefore adapted to varying conditions of climate and soil. In India it is cultivated in the plains as well as in the higher regions of the Himalayas up to 14,000 feet. It, however, does not thrive well in the warm and humid regions of the country such as in Madras, Bengal and Assam. It is therefore a crop which requires a warm and dry climate. It requires less water than either wheat or oats, and also a shorter-growing season. Because of the latter character it is possible to grow it in the northern regions of the world. Barley also can withstand more alkalinity in the soil than wheat. In most parts of the United Provinces it is grown in soils which are too light or otherwise not very favourable for the growth of wheat. But while barley will grow well on poor soils, it does best on soils that are well supplied with fertilizing elements.

*Classification*—The barleys have been classified by



several workers since the time of Linnaeus, but the classification by Harland in 1918 seems to be the most satisfactory. His key for the common cultivated barleys is as follows:

KEY TO THE SPECIES

- A. All spikelets fertile (6-rowed barley).
  - B. Lemmas of all florets awned or hooded.....*vulgare* L.
  - BB. Lemmas of lateral florets bearing neither awns nor hoods.....*intermedium* Kcke.
- A. Only the central spikelets fertile (2-rowed barley).
  - B. Lateral spikelets consisting of outer glumes, lemma, palea, rachilla and usually rudiments of the sexual organs.....*distichon* L.
  - BB. Lateral spikelets reduced, usually to only the outer glumes and rachilla, rarely more than one flowering glume present, and never rudiments of sexual organs.....*deficiens* Steud.

As mentioned previously in this chapter, the two forms of barley which occur in this country are the six-rowed and the two-rowed barleys; but of the six-rowed types, *Hordeum vulgare* L. and of the two-rowed barleys, *H. distichon* include all the types which occur in this country. According to Bose, who has classified the Indian barleys, *Hordeum vulgare* is sub-divided into the variety *Pallidum* the hulled barleys, and the variety *Caeleste*, the hull-less barleys. In the former there are altogether 18 different types, but *Caeleste* is represented by only one type. The two-rowed barleys have been classified by him into five different types. Thus there are, according to him, 24 separate types altogether.

*Cultural methods*—The preparation of the land for the cultivation of barley is not as thorough as in the case of wheat. The number of ploughings is much less than in the case of wheat. Using an improved plough, one ploughing followed by harrowing is regarded as sufficient preparation for the seed-bed for barley.

In most parts of the United Provinces and the Punjab

barley is frequently sown mixed with gram, and the combined crop is known as *berra*. Occasionally it is also sown mixed with such crops as wheat, linseed, peas and mustard.

When sown alone the amount of seed per acre varies from 60 to 120 lbs. The high seed rate is probably necessary because of the deterioration of the seed in storage. This is believed to be due to the exposure of the seed to high humidity during the monsoon.

Barley is usually sown in the United Provinces more or less at the same time with wheat, but it may also be sown earlier or later. The crop takes less time to mature than wheat. Hence when sown in October it is generally harvested in March or in the beginning of April.

Weeding is not generally practised, and irrigation is seldom given.

The method of harvesting is also similar to that of wheat. It consists in cutting the crop with sickles when fully ripe. But as the crop shatters more easily than wheat, it is usually harvested in the forenoon before the heads become too dry and fragile for handling. The crop is then taken to the threshing floor where the bullocks are made to tread on it. The grain is separated from the chaff by winnowing.

*Diseases and pests*—Barley is subject to a number of fungous diseases, of which the most common and more widely distributed in this country is probably the covered smut (*Ustilago Hordei*). The other diseases which are also found to attack the crop are loose smut (*Ustilago nuda*); rusts (*Puccinia simplex*, *Puccinia graminis* and *Puccinia glumarum*), *Helminthosporium* diseases caused by *H. gramineum* and *H. teres*, and powdery mildews (*Erysiphe graminis*). With the exception of covered smut, the rest are probably of minor economic importance.

Covered smut appears in the ears of barley as black covered masses, which are spores of the fungus enclosed within an ovary wall. There are several methods adopted for the control of this disease, but the most common is the use of a formalin solution (1 lb. of commercial formalin

in 40 gallons of water). The seed is moistened by sprinkling and is kept moist for four hours.

Barley is more or less free from the attack of insect pests. But in general those that attack wheat would also attack barley.

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CHAPTER XIV

BAJRA

*Origin and history*—The origin and history of *bajra* is still very imperfectly known. It seems very probable, however, that the plant originated either in India or Africa, as the crop is widely cultivated in the various regions of the two places mentioned. But the crop is also cultivated in Arabia and Southern Europe, and more recently has been introduced into the United States of America, where it is being grown mostly for fodder purposes.

*Distribution in India*.—In India, the crop is grown in most parts of the country except Eastern Bengal and Assam. It is generally grown in areas of low rainfall and in soil too poor for *jowar*. The following table shows the distribution of *bajra* in provinces and States of India.

TABLE 15  
Showing the Distribution of Bajra in India

Provinces and States	Area in thousand acres in		Yield in thousand tons in	
	1937-38	1940-41	1937-38	1940-41
Madras .. .. .	2,572	2,559	663	624
Bombay .. .. .	3,542	4,087	419	492
United Provinces .. .. .	2,096	2,435	323	443
Punjab .. .. .	2,615	3,863	239	407
Hyderabad .. .. .	2,108	2,110	124	121
Sind .. .. .	842	711	103	84
Bihar .. .. .	62	60	26	24
C. P. and Berar .. .. .	101	110	26	26
N.-W. F. Province .. .. .	94	135	18	18
Delhi .. .. .	49	65	7	13
Mysore .. .. .	66	60	7	8

The figures given above do not show the acreage and total production from the Rajputana States, as figures are not available. But in general, it may be said, that the area under *bajra* in the drier parts of Rajputana represents about 40 to 60 per cent of the total cultivated area in those regions.

*Botanical description*—*Bajra* is a member of the family of grasses (*Gramineae*). Several scientific names had been given to it in the past, but the one most commonly adopted at the present time is *Pennisetum typhoideum*. It is known in English by several names such as pearl millet, cat-tail millet and bulrush millet. In India also it is called by the name of *cumbu* or *sajja* in South India, or *bajri* in several parts of Northern India.

The stems of *bajra* stand erect and are usually 3 to 8 feet tall. Tillers are not common but they may sometimes arise, depending usually on the spacing and also on the variety. The plants also sometimes produce axillary branches, but these are not as vigorous as the tillers and may only develop two or three internodes. It has been found that conditions favouring tillering are also favourable for the development of branches.

The leaves of *bajra*, like those of all grasses, consist of a blade or lamina and a sheath. The blade is lanceolate and long-pointed, and possesses numerous hairs on both surfaces. The sheath which is a little thicker than the lamina clasps the stem almost completely. The ligule, which is a structure at the juncture of the blade and the sheath and occasionally known as the rainguard, is about four or five mm. in length.

The inflorescence of *bajra* is a compound spike with an unbranched tapering central axis. The length of the inflorescence is usually six to fourteen inches, except in one variety, known as Jamnagar Giant whose inflorescence is about 2 feet or more in length. The branches on which the flowers are borne, known as rachillae, may contain from two to five spikelets each, but the most common number is two. The inflorescence bears two types

of flowers, hermaphrodite and staminate. The former are the first to appear.

Soon after the emergence of the inflorescence (head), the styles begin to protrude out of the glumes. The anthers begin to push out after the styles have started to dry up. This protogynous nature of the inflorescence makes the plant more susceptible to cross-pollination. It can therefore be safely assumed that there is a great deal of cross-fertilization taking place in this crop.

The seed is a small grain about 3 to 4 mm. long and 3 to 10 mgm. in weight. It is somewhat flattened on the sides, but more or less oval in appearance, with one end somewhat tapering. The colour of the seed varies from pale yellow to dull light blue.

The root system is, like that of most grasses, fibrous. The roots which go downwards are generally thicker than those which sprouted out laterally. But on the whole the plant is shallow-rooted and may be considered as a surface feeder.

*Ecological factors*—*Bajra* is grown in India as a *kharif* (monsoon) crop, but more usually as a catch crop; that is, it is grown when the amount of rainfall during the *kharif* season has not been sufficient for other crops like *jowar*. The plant therefore does not require very much water and will thrive best in sandy loams, or well-drained light soils. *Bajra* can also grow well in soils which are too poor for most other cereals.

The crop will do best under conditions of light showers followed by bright sunshine during the period of its growth.

*Classification*—*Bajra* has not been classified systematically like most other crops. The characters considered in naming local varieties are the length of the head or spike, the presence or absence of awns, that is, whether hairy (bristled) or non-hairy, and the number of days the plants take to mature, that is, whether early or late.

*Cultural methods*—The preparation of the land on which this millet is to be sown is not as thorough as for the seed bed for *jowar*. The land is usually ploughed two or three times before sowing. The seed is usually sown mixed with other crops, more usually pulses, such as the pigeon pea, *urd* and *mung*, or with sesamum, etc. The seeds are either broadcast or sown in lines. The amount of seed used per acre when sown alone varies from six to ten pounds, but when sown with other crops it is much less. The crop ordinarily is not weeded, and no irrigation is given.

The crop, when grown for grain, is harvested when the heads are ripe, but when grown for fodder, it is cut before the stalks become too dry. The plants are cut by means of sickles as near the ground as possible, and the heads are taken to the threshing floor where the bullocks tread the seed out. The grain is cleaned by winnowing.

*Diseases and insect pests*—The most common disease which occurs on *bajra* in this country is known as the "green ear" disease. This is caused by a fungus known as *Sclerospora graminicola*. The disease, as the name suggests, usually appears in the form of a mass of small twisted green leaves instead of the grain in the spike or head. The disease may affect part or all of the head. In severe cases, only shredded leaves may appear in place of the head. In the early stages of the growth of the plant the leaves appear whitish and later turn brown.

The disease occurs almost everywhere where *bajra* is grown, but the attack usually is not very serious.

The only method of control known is the prevention of the dissemination of the spores, by the removal of affected plants.

The other diseases that are known to damage *bajra* plants are rust (*Puccinia Penniseti*) and smut (*Tolyposporium Penicillaria*).

No insects are known to seriously damage the *bajra* crop.

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## CHAPTER XV

## MAIZE

*Origin and history*—Maize is undoubtedly of American origin. The plant has not been found in the wild state, but it is generally believed that teosinte (*Euchlaena Mexicana*) with which it is known to cross readily is its ancestor. Its introduction into India probably occurred about the beginning of the seventeenth century during the early days of the East India Company. The crop is now cultivated almost throughout the country, and is the staple food of a large number of people in Northern India in the hilly tracts.

Maize is now grown mostly in the United States of America, Argentina, Roumania, Italy, India, Hungary, the Union of South Africa and Egypt.

*Distribution in India*—The following table shows the distribution of maize in the provinces and States of India.

TABLE 16  
Showing the Distribution of Maize in India

Provinces and States	Area in thousand acres in		Yield of grain in thousand tons in	
	1937-38	1940-41	1937-38	1940-41
United Provinces .. ..	1,948	2,120	730	781
Bihar .. ..	1,553	1,407	445	400
Punjab .. ..	1,103	1,144	406	423
N.-W. F. Province .. ..	471	471	220	214
Hyderabad State .. ..	651	682	108	116
C. P. and Berar .. ..	152	152	88	95
Bombay .. ..	164	186	49	70
Madras .. ..	72	68	31	30
Bengal .. ..	74	85	24	26
Ajmer-Merwara .. ..	52	60	11	14
Orissa .. ..	29	31	7	8

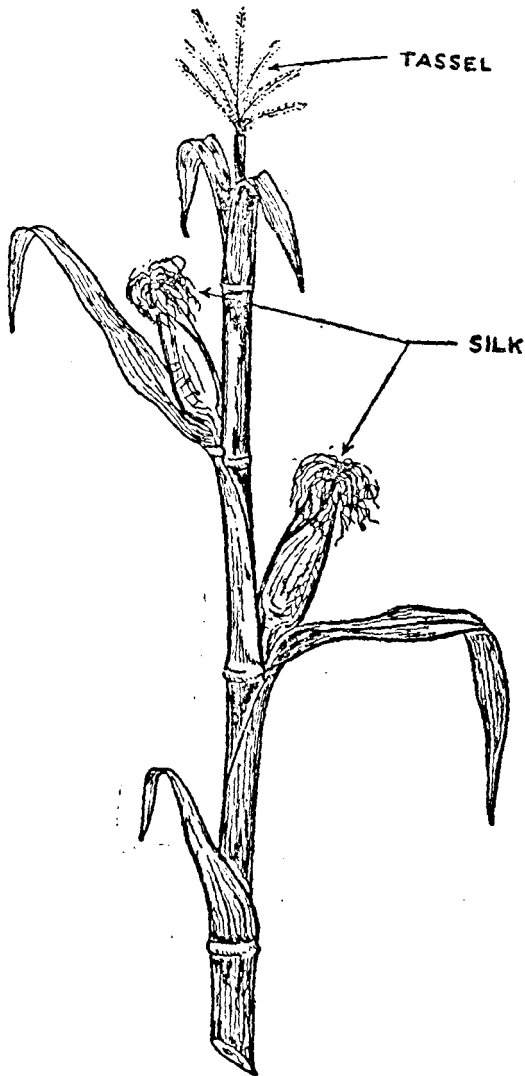


Figure 13  
Part of the maize plant showing the pistillate and  
staminate flowers.

*Botanical description*—Maize (*Zea Mays*) is a member of the family of grasses (*Gramineae*). It is a tall herbaceous annual, but its height is very variable, more so than that of any other cereal. The average height varies from 5 to 10 feet but some may attain a height of 25 feet or more.

The stem is made up of a succession of nodes and internodes, and, unlike the stems of most cereals, it is completely filled with pith. The internodes are somewhat flattened or grooved on the side next to the leaf-sheath.

Maize plants often produce tillers. This habit of tillering has been found to be hereditary, but is also greatly influenced by soil and climatic conditions.

The leaves of maize develop alternately on opposite sides of the stem. The number of leaves varies from 10 to 20. The width varies greatly with varieties.

The inflorescence in maize is of two types: (1) the pistillate inflorescence which develops into an ear, and (2) the staminate inflorescence which contains the male flowers. The pistillate or female inflorescences are borne at the side of the plant usually above the middle of the stem, but the staminate or male inflorescence always occurs at the top of the stem. The number of pistillate inflorescences in a single plant, that is, the number of ears, may be more than one per stalk, but the staminate inflorescence is always terminal and therefore only one per stalk.

The pistillate inflorescence is borne on a short branch called the "shank." The branch bears modified leaves which enclose the ear and are collectively known as the "husk". The pistillate spikelets are borne on a thick axis called a "cob." Each pistillate spikelet produces two flowers, one of which is abortive. The other flower bears the usual parts of a pistillate flower, which include the glume and palea, an ovary, the style and stigma. The ovary develops into a mature kernel; the styles are very long, and emerge through the husk and are collectively known as the "silk"; the stigma is the receptive portion at the end of the style.

Maize is ordinarily cross-pollinated, but self-pollina-

tion frequently occurs. Pollination may be brought about by wind or gravity.

The grain of maize is a mature ovary, and is, therefore, morphologically a fruit; that is, the ovary wall adheres tightly to the seed coat.

The root system of maize is usually well developed. The lateral roots branch profusely, spread widely, and penetrate deeply into the soil. But the depth to which the roots penetrate or the distance to which they spread is greatly influenced by the moisture conditions in the soil. In somewhat dry soils the roots penetrate deeply.

Besides these ordinary roots, maize possesses another type known as adventitious roots. These arise above the surface of the soil on the first two or three nodes and grow obliquely downwards penetrating the soil and help to anchor the plant more firmly into the soil. Hence they are sometimes known as "prop" or "brace" roots.

*Ecological factors*—Maize is grown in many parts of this country as a *kharif* crop. It is a crop that requires plenty of moisture in the soil during the early stages of its growth, followed by sunshine. The crop, if stunted during the early stages of its growth due to a lack of moisture, will not be able to recuperate fully, and will therefore remain more or less stunted. The distribution and amount of rainfall in July and August greatly influence the yield.

The soil best suited for the growing of maize is a well-drained fertile soil. It will not do well on heavy clay soils, nor on very light soils.

*Classification*—Maize (*Zea Mays*) has been divided into six classes, mainly on the character of the horny endosperm, and whether the husk covers the individual grains or not. The following key is given as an aid for the recognition of these classes.

## \*KEY TO THE "CLASSES" OF MAIZE\*

- A. Husk covering each individual kernel . . . . . *Zea Mays tunicata*.
- AA. Husk not covering each individual kernel.
  - B. Grain possessing exceptional popping properties  
.....*Zea Mays everta*.
  - BB. Grains with little or no popping properties.
    - C. Grains soft.....*Zea Mays amylacea*.
    - CC. Grains hard.
      - D. Grains shrivelled or wrinkled.....  
.....*Zea Mays saccharata*.
      - DD. Grains smooth.
        - E. Kernels dented on top..*Zea Mays indentata*.
        - EE. Kernels not dented on top.....  
.....*Zea Mays indurata*.

1. *Zea Mays tunicata* is a primitive type and is not grown commercially. This is sometimes known as pod corn in America.

2. *Zea Mays everta* is commonly known as pop corn in America as it possesses exceptional popping qualities. The ears are small, and kernels are small and pointed. This is an exotic variety in this country.

3. *Zea Mays amylacea* is sometimes known as soft corn as it does not possess a hard endosperm, and in the absence of which the kernels become soft.

4. *Zea Mays saccharata* is the common sugar or sweet corn, and is usually grown in home gardens. The grains possess a considerable amount of sugar which makes them shrivelled or wrinkled when they are dry.

5. *Zea Mays indentata* or dent corn is so called because of the dent or pit-like formation on the top of the grain. This is the most common type of maize in the United States of America.

6. *Zea Mays indurata* or flint corn, as the name suggests is very flinty or hard and smooth. It is the type most commonly cultivated in India.

\* Adapted from Robbins "Botany of Crop Plants."

*Cultural methods*—In the plains the usual method of preparation of the land for sowing is to plough the land after the first shower of rain two or three times. The land should also be well manured. The seeds are then either sown in lines or broadcast. When sown in lines the distance between them is about 18 inches, and the distance between plants in the lines is usually 9 inches. The amount of seed per acre is usually about 10 to 15 lbs. Occasionally the seeds are sown by dropping them in a furrow made by a plough.

Maize is sometimes grown as an irrigated crop, especially near large cities where it is grown for the green ears used as vegetables, and when an early crop is wanted.

Maize requires thorough weeding and usually two or three cultivations during its growth.

If maize is grown for green ears, the ears are harvested while they are still green, and the stalks are cut and fed to cattle. When grown for seed it is best to leave the ears in the field until they are fully ripe. The ears are then harvested by breaking them off the stalks, and are allowed to dry. This is usually done near the cultivators' home where they can be carefully watched. When dry, the grain is shelled from the cobs usually by hand. When kept for seed it is best to store the seed on the cobs in dry and well-ventilated room. The stalks left in the field are cut as near the ground as possible by sickles and tied in bundles and later made into *kadbi* (chopped fodder) and fed to cattle.

*Diseases and pests*—The maize crop in India is subject to the attack of several fungous diseases. Some of which are: (1) the head smut (*Ustilago Reiliana*) which attacks the male as well as the female inflorescence, causing the tassel or the ear to be converted into a mass of black spores or smut ; (2) the common smut of maize (*Ustilago Zeae*), which causes tumours in place of grains on infected plants; (3) the downy mildew (*Sclerospora Maydis*), which usually attacks the young seedlings, making the infected parts of the plants whitish in long streaks;

(4) the rust (*Puccinia Maydis*) which appears on the leaves as innumerable rusty brown spots, causing the plants to droop; (5) leaf blight (*Helminthosporium turcicum*) which appears on the leaves as small, yellowish, round or oval spots; and (6) a disease caused by *Colletotrichum gramini-colum* which appears in the form of small brownish spots on the upper side of the leaves.

These diseases are not known to do very serious damage to the crop, except in very restricted localities. The control of most of these fungous diseases seem to lie in the direction of the selection of resistant strains.

The insect pests which attack maize are usually those which also attack *jowar* and sugarcane, and have, therefore, been dealt with in connection with those crops.

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## CHAPTER XVI

### SESAME OR TIL

*Origin and history*—Sesame, according to most investigators, originated in southern and south-western Africa where all the wild and cultivated species of the genus *Sesamum* are found to occur. From there it is believed to have spread northward to Abyssinia whence it found its way into India, probably before the Aryans came into this country.

The diversity of ecological factors in this country is believed to have given rise to a multitude of forms which spread eastwards to China, Indo-China and Japan and westwards through Afghanistan to various parts of Western Asia, the Mediterranean regions and to Northern Africa. Thus India is a secondary centre of origin of the multitudinous forms now cultivated in various parts of the world.

*Distribution in India*.—Sesame is grown in all parts of India. The areas where it is most intensively cultivated are in Burma, but its distribution in India according to provinces is as given in the table below.



TABLE 17

Showing the Distribution of Sesame in India

Provinces and States .	Area in thousand acres in		Yield in thousand tons in	
	1937-38	1940-41	1937-38	1940-41
Madras .. ..	795	786 ..	77	103
Bombay (including States) .. ..	544	162 †	76	19 †
Bengal .. ..	210	173	46	33
Bihar .. ..	114	117	17	13
C. P. and Berar .. ..	483	477	40	39
United Provinces .. ..	368	283	32	27
Hyderabad .. ..	548	529	40	38
Punjab .. ..	95	74	7	7
Baroda .. ..	53	61	3	4
Orissa .. ..	112	100	10	9

† Native States, not included.

*Botanical description*—Sesame belongs to the genus *Sesamum*, one of the 14 genera of the *Pedaliaceæ* or pedaliium family, of which *Sesamum indicum* is one. The plants in the family are covered with peculiar slime-secreting glands.

Sesame is a herbaceous annual with an average height of about three to four feet. Certain strains, however, may reach a height of about 6 feet. The stems are erect, angular and striate. The upper part of the stem is particularly covered with short hairs. Branching varies widely with different types; some do not branch at all, whereas in the branched varieties the degree of branching varies considerably. Some branch profusely, the primary branches beginning near the base and continuing upwards almost to the top of the main stem. Similarly these primary branches produce secondary branches. This profuse branching gives the plant a bushy appearance in certain varieties. The unbranched varieties flower early and consequently require a short-growing period, whereas the bushy

types flower late and therefore require a longer-growing period.

The leaves may be entire or divided. When divided, they may be slightly or deeply incised or dissected. The leaf margins may be entire or dentate. The leaves also vary greatly in width, some being narrow, others intermediate, broad or very broad. The arrangement of the leaves on the stem may be opposite, alternate or mixed. The shape and size of the leaves also vary considerably in the same plant. Usually the lower leaves are the broadest while the upper ones are narrow. The surface of the leaf is generally glabrous but in some it may be pubescent. The colour of the leaves also varies from light to dark green.

The inflorescence is a raceme, and the flowers are borne in acropetal succession, in the axils of the upper leaves, either singly or in groups of two or three. The flowers vary in size and colour and in the makings inside the tube, but are always hairy. The flower is tubular and two-lipped, composed of five lobes, the two lobes of the upper lip being shorter than the three lobes of the lower. The colour of the corolla varies from white through pink to purple. The hairs on the corolla may be short, intermediate or long.

In sesame, self-pollination is the rule, but considerable natural cross-fertilization takes place, in which it is believed that insects, particularly bees, play a part. The amount of natural cross-fertilization at Lyallpur in the Punjab has been estimated to be about five per cent. One of the peculiar phenomena which commonly occurs in the flowers of sesame, is the modification of the flowers in various ways causing sterility. This phenomenon is known as sepaloidy.

The number of locules in a capsule may vary from four to six, eight or occasionally ten. The number of locules in the same plant may vary.

The fruit of sesame is a capsule in which the number of carpels may be two or four. The varieties therefore

belong to one or other of the sub-species *bicarpellatum* or *quadricarpellatum*.

The arrangement of the capsules on the stem may be lax, intermediate or dense. Numerous seeds are borne in the capsule. These vary greatly in colour and size and in the surface of the seed-coat. The common colours are white, brown and black and their various shades. The size of the seed may be small, medium or large, and the seed-coat is either rough or smooth.

In sesame two types of root systems are recognized. In the early-maturing types, the root system is poorly developed. The depth to which the roots penetrate the soil is about three feet. They bear only a few secondary and tertiary roots. In the late-maturing varieties, the main root goes deeper and bears an enormous mass of secondary and tertiary roots near the surface of the soil. So there is a distinct correlation between root and shoot development.

*Ecological factors*—The cultivation of sesame extends beyond the tropical countries where short-season varieties are grown. In India it is grown in the colder regions as a *kharif* crop and in the warmer regions as a *rabi* crop. The crop will do best in a well-drained fertile soil, but more often it is grown on poor and lighter soils. Continued heavy rain is detrimental to its growth.

*Classification*—The first serious attempt at the classification of the Indian sesames is that by Kashi Ram in 1930. He classified them on the basis of the number of flowers in a leaf axil, seed colour, corolla colour and markings, and the time taken to reach maturity. On the basis of this classification he classified thirty different types.

Using more or less the same method of classification, Ali Mohammad and Zafar Alam in 1933, classified thirty-four different types of sesame in the Punjab.

Rhind and Thein, also in 1933, working with the Burmese sesames, classified them into forty-nine different types mainly on the basis of the maturation period (late

or early), presence or absence of branches, colour of seeds, and number of capsules in an axil.

A more extensive classification of the world sesames was made by the Russian workers of the Institute of Applied Botany, who collected specimens from all parts of the world. According to this classification the cultivated sesames were divided into two main groups on the basis of the number of carpels in the capsule, that is, whether two or four, which are called sub-species *bicarpellatum* and *quadricarpellatum* respectively. The former was further sub-divided into 79 varieties, and the latter into 32. Out of the total samples collected, 28 were Indian varieties.

*Cultural methods*—The crop is cultivated as a *kharif* crop in the colder parts of the country and as a *rabi* crop in the warmer parts. When grown as a *kharif* crop, it is usually sown in June and July and harvested in October and November. But when grown as a *rabi* crop it may be sown in September or October. In Madras, if irrigated, it may be sown in January or February. The method of preparing the seed-bed consists in ploughing two or three times, but the preparation is not as thorough as for most of the *kharif* and *rabi* crops. The crop is usually grown with other crops such as *jowar*, *bajra* or cotton, and it gets the benefit of the care which these crops receive. Whether sown alone or mixed with other crops, the seed is generally sown broadcast, or sometimes it is sown in parallel lines across the field or along its borders. When sown alone the amount of seed per acre is about 16 to 20 lbs., but when sown mixed it requires much less.

The crop is harvested before the plants are fully ripe. This prevents shattering and the dropping of seeds from the open capsules. The plants are cut with sickles, tied in bundles and taken to the threshing floor where they are stacked upright. After several days (about a week) when they are dry, the heads are turned downwards and shaken. The seeds all fall out from the open capsules. If all the capsules are not open, this operation may have to be re-

peated. The seed is then cleaned by winnowing.

*Diseases and pests*—The crop is practically free from the attacks of fungi. The peculiar phenomenon, described previously in this chapter, and called sepaloidy is believed by some to be caused by a virus.

The only pests known to do some damage to the sesame crop in this country are (1) the "til sphinx" (*Acherontia styx*) which is a large green caterpillar with yellow stripes and a horn-like projection on its hind end, and (2) the caterpillar of a moth known as *Antigastra catalaunalis*.

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CHAPTER XVII  
MINOR LEGUMES

Some of the important leguminous crops grown in this country have been dealt with in previous chapters. In the present one are included those leguminous crops which are of comparatively minor importance in this country. These are: (1) sunn-hemp, (2) lentil, (3) *mung*, (4) *urd*, (5) cowpea, (6) soybean, (7) peas, (8) *khesari* and (9) *moth*.

SUNN-HEMP

Sunn-hemp (*Crotalaria juncea*) has probably been grown in this country from very early times. It is found throughout the plains of India and is grown either as a fibre crop or as a crop for renovating the soil.

It is difficult to get estimates of the total acreage under this crop since it is usually grown in long strips around fields, and is sometimes classed under "fibres" or under "hemp".

The plant grows to a height of about four to eight feet depending on the fertility of the soil. Its branches are slender and somewhat silky. The leaves are rather far apart on the stem, shining, and with short silky hairs. The inflorescence is a raceme usually of twelve to twenty yellow flowers. Extensive cross-fertilization takes place in this crop, and self-pollination has been found not to occur if the stigmatic surface is not stimulated by insects or by some other means.

In most parts of India sunn-hemp is a *kharif* crop, being sown at the beginning of the rains, but in Madras it may be sown as early as February. The type of soil on which it is generally grown is a light loam. It is not grown on heavy clays or on water-logged soils.

Whether the crop is grown for fibre or for green-manuring, a quick growth is necessary. This is obtained by a thorough preparation of the seed-bed. Ploughing usually begins with the first rains, and the seed is sown as soon as the soil is moist enough for the proper germination of the seed. The amount of seed per acre whether sown for fibre or for green manuring is practically the same. But the exact amount varies with different localities, 50 lbs. being about the average used per acre. After the sowing of the seed, usually the crop requires no more care or weeding.

When grown for green-manuring, the crop, when about 2 or 3 feet high, is run over by a heavy beam or planker in order to make it lie flat on the ground in the direction in which the ploughing will be done. The crop is then ploughed under by means of a mould-board plough. This operation should be done while the plants are still succulent and while the ground is quite moist in order to ensure the rapid decay of the crop.

When grown for fibre the crop is sometimes harvested when in full bloom. In other cases it is allowed to remain in the field until the fruits have developed or in some cases until the crop is dead ripe. The best fibre is believed to be obtained when harvested before the plants are quite ripe. Harvesting is done by cutting the plants as near the ground as possible by means of sickles. The cut plants are allowed to remain in the field exposed to the sun for two or three days until the leaves have shed. The stalks are then tied in bundles of convenient size and stacked for some days. The bundles are then placed in water about two feet deep, only the lower portions being covered. This is to allow the thicker portions more time for retting. Later the whole bundles are immersed, weighted down, and left until the bark separates easily from the stem. The plants are then taken out and dried, and the fibre is extracted by hand.

One of the diseases which commonly attack this crop is known as wilt and is caused by a fungus (*Fusarium vasin-*

*sectum*). The only method of control which is followed at present is the growing of resistant strains. A strain evolved in the United Provinces and known as Cawnpore 12 is reported to be fairly resistant to this disease.

### LENTILS OR MASUR

The lentil (*Lens esculenta*, Moench) is one of the most ancient cultivated plants. Linnaeus called it *Ervum lens*. But modern botanists are inclined to include the genus *Ervum* as but a section of the genus *Vicia*, and to separate the lentil into another genus. The scientific name *Lens esculenta* is used here.

According to Helena Barulina, the centre of origin of the cultivated lentil is probably the region between the Hindu Kush mountains and the Himalayas. Its area of cultivation embraces several countries in Asia, Europe, Africa and in North and South America.

In India it is cultivated in most parts of the country, but it is grown more especially in the Central Provinces, Madras, the United Provinces, Bengal and Bihar.

Lentils are annual herbaceous plants varying in height from about 6 to 24 inches, and are usually more or less erect, the general habit of the plants depending on the mode of branching, the height and the amount of foliage. The stems are usually angular and possess short hairs, the degree of hairiness varying with different varieties. The stems may be entirely green or possess anthocyanin pigments at the base.

The leaves are pinnately compound with 2 to 8 pairs of oval or linear leaflets, and terminating in a tendril. The leaves are also stipulate.

The inflorescence is a raceme consisting of 1, 2, 3, or occasionally four flowers. The colour of the flowers may be white, pink or violet, the most common being white with violet-blue veins of varying intensities. Self-fertilization is the rule, but natural cross-fertilization may occur due to the visitation of such insects as bees and butterflies.



The root system has been found to be of three types. One type which represents the group grown in the black cotton soil is a deep root system with few laterals near the surface of the soil. Another type which represents the group found in the Gangetic alluvium is a shallow root system, but with well-developed laterals near the surface of the soil. The third type is intermediate between these two, and represents the group found in the Indus alluvium in the Punjab and the North-west Frontier Province.

The lentil crop is grown over a very wide range of climate and soil. In this country it is generally grown as a cold season crop mostly on the low-lying lands.

The lentils of this country have been classified by Shaw and Bose, mainly on the basis of the seed colour, the degree of mottling of the seed, the colour of the hilum, size of the seed and the colour of the flowers. According to this classification, 66 different types of lentils have been identified.

Helena Barulina has classified the lentils of the world into two principal geographical groups or sub-species known as *macrosperma* and *microsperma*. The first are large-seeded, and the latter are small-seeded. The main characters which also distinguish these groups are the size of flowers, pods and seeds, and the shape of the pods. These groups are further divided on the basis of such characters as "the degree of dehiscence of the pods, pubescence of the plants, relative length of the calyx teeth, number of flowers per peduncle, character of branching and colour of flowers". In this classification 39 different characters were used, instead of 7 or 8 used by Alefeld who first made an attempt in the classification of lentils.

The seed bed for the sowing of this crop is roughly prepared, two or three ploughings being considered sufficient. The seed is then sown broadcast at the rate of about 20 to 25 lbs. per acre when sown alone. But when sown mixed with such crops as barley and mustard the amount of seed is approximately half of the usual seed rate. Harvesting, threshing and winnowing is

done as in the case of most *rabi* crops.

The lentil crop in this country is usually subject to an attack of rust caused by *Uromyces Fabae*, a fungus which is known to attack peas also. The damage done by this fungus on the lentil crop is, however, usually slight.

Lentils, however, are associated with a weed known as vetch (*Vicia* sp.) which is very similar in appearance to the lentils and *kebesari*. (*Lathyrus* sp.). Their presence in the crop is sometimes considerable and consequently impairs its quality. The similarity of the weed to these crops is an outstanding example of mimicry in plants, and affords a very good example in support of the "Law of Homologous Series" as applied to plants, and first enunciated by Professor N. I. Vavilov.

As an aid to the identification of these three genera of legumes, the following key is given below, which is adapted from Bailey.

- A. Wings of corolla free, or essentially so, from keel....*Lathyrus*.
- AA. Wings of corolla adherent to keel, half or more their length.
  - B. Lobes of calyx long subulate, style bearded down inner face.....*Lens*.
  - BB. Lobes of calyx short and broad, style bearded in tuft or ring at the apex.....*Vicia*.

#### MUNG OR GREEN GRAM

*Mung* or green gram is probably indigenous to this country. Its cultivation in Africa is of a more recent date. It is an important crop only in this country and to some extent in South-Eastern Asia. Its cultivation in India is widespread, but it is grown as a minor crop in association with other crops like cotton, maize, *jowar* and other millets.

The scientific naming of *mung* has been considerably confused, but it seems that the consensus of opinion among botanists is that the name *Phaseolus radiatus* Linn. should be applied to it, and that the scientific name *Phaseolus mungo* should be applied to *urd*.

*Mung*, also more commonly known as green gram, is a small herbaceous annual growing to a height of about 1 to 3 feet. The central stems are more or less erect. The side branches are sub-erect. The leaves are trifoliate, the leaflets being large, ovate and entire. Both the stems and leaves are covered with short hairs, but the hairs are generally not as long as those in *urd*. The flowers possess various shades of yellow colour, and are produced in a cluster. The pods are slender and about  $2\frac{1}{2}$  to 4 inches long. The seeds are small and nearly globular. The colour of the seeds is usually green, but yellow and brown seeds also occur. The hilum or scar in *mung* is not concave, and is in that respect different from that of *urd* which possesses a concave hilum. Two types of root systems are found in the *mung* plants. The first, called the mesophytic type of root system, possesses numerous laterals near the surface of the ground, whereas, in the xerophytic type, the lateral roots arise from the main root and extend obliquely downwards.

*Mung* is generally grown in this country as a *kharif* crop, but in some parts of the country, such as the Bombay Presidency, it is also sown as a cold season crop. The soils on which it is cultivated are usually loams which are deep and well-drained.

A classification of *mungs* or green grams in this country was made by Bose in 1932. He classified them into 40 different types mainly on the basis of the colour of seeds, flowers and pods.

*Mung* or green gram is usually sown mixed with other crops such as *jowar*, *bajra*, or cotton. It is believed to have the same restorative effect on the soil as the pigeon pea or gram. The seed-bed preparation is similar to that for *jowar* and cotton. The seeds are usually sown broadcast, and the amount of seed when sown alone is about 8 to 10 lbs. per acre. As it is grown in the monsoon season, it is not an irrigated crop.

The crop is harvested before it is fully ripe as there is a danger of the shattering of the dry pods. The plants

are cut by means of sickles and removed to the threshing floor and dried. The grains are then threshed by means of bullocks, and cleaned by winnowing from baskets.

The crop is fairly free from the attacks of fungous diseases and insect pests, but is sometimes susceptible to the attacks of leaf spot (*Cercospora cruenta*), rust (*Uromyces appendiculatus*), powdery mildew (*Erysiphe polygoni*), chlorosis (a physiological disease), the caterpillar of a moth (*Diacrisia obliqua*), and aphides:

#### URD OR BLACK GRAM

*Urd* or black gram is in all probability a native of India. It is to-day cultivated in many tropical and subtropical countries of the world. Thus it is now found in several regions in Africa, the southern countries of Europe, and in the tropical regions of the New World.

In India the crop is grown in most parts of the country and is one of the most highly valued pulses of India. The scientific naming of *urd* has been somewhat confused with that of *mung*, but most botanists now are agreed that the name *Phaseolus mungo* Linn. var. *Roxburghii* Prain should be given to *urd*, as this was first described by Linnaeus under the name of *mungo*.

The plant is a spreading annual with procumbent branches and is, to all appearances, very much like *mung* or green gram. The stems and branches possess fairly long brown hairs, and it is, for that reason, known in some parts of the world as the "woolly pyrol". These hairs are usually longer than those in *mung* or green gram. The leaves are large, trifoliate and also hairy, generally with a purplish tinge. The colour of the leaves is green to dark green but usually lighter than that of *mung*. The leaflets are broad, ovate and entire. The inflorescence consists of a cluster of five to six flowers at the top of a long stout hairy peduncle. The corolla is pale or lemon yellow. The plants are almost universally self-fertilized, fertilization taking place even before the flowers open in a great many cases. The pods are about two or more

inches in length, cylindrical and more or less curved, and are generally covered with fairly long hairs, longer than in *mung*. The seeds are oblong in shape and are either black or green, with a concave hilum which character distinguishes *urd* from *mung*.

The root system of *urd* is of two types, the shallow or mesophytic and the deep-rooted or the xerophytic type.

*Phaseolus mungo* or *urd* requires a fairly warm growing season, and is consequently grown in this country as a *kharif* crop, but in some parts it is also sown in February and harvested in May. The plant is believed to prefer a heavier soil than *mung*, but may sometimes be grown on light soils as is sometimes done in Bihar.

The black grams of India have been classified by Bose into two sub-species, one of which possesses large black seeds and hence named by him as *Niger*, and the other somewhat smaller and greenish seeds and hence named by him as *Viridis*. The black-seeded *urds* have been found to be early-maturing varieties, whereas the small green-seeded *urds* more commonly known as *urdi* (a diminutive of *urd*) are the late-maturing varieties. Then he further sub-divided *Niger* into 10 different types mainly on the basis of the colour of the seeds, the colour of the flowers and habit of growth of the plant. On the same basis, the sub-divided *Viridis* into fifteen different types. Thus the Indian *urds* have been classified by him into 25 different types.

The preparation of the land for sowing is similar to that for the *mung* crop. It consists of two or three ploughings at the commencement of the rains. Thorough preparation of the seed-bed is not considered necessary, as this tends to encourage excessive vegetative growth at the expense of seed development. The seeds are then sown broadcast at the beginning of the rains. Both the green and black varieties are sown at the same time. The black ones ripen in August and September, whereas the late-maturing green-seeded varieties ripen in October or

November. When sown alone the seed rate for this crop is from 8 to 12 lbs. per acre, but when sown as a mixed crop with millets, cotton, maize or any other crop, the seed rate is very much less.

Harvesting is done in the usual way as in the case of the *mung* crop.

The same diseases which attack the *mung* plants sometimes attack this crop also.

### COWPEAS

The cowpea is probably a native of Central Africa, as throughout most of that continent wild plants resembling the cultivated cowpeas have been found, and these plants also cross readily with the cultivated ones. It is now grown in most parts of the world and is one of the most popular leguminous crops used in rotations in the United States of America. In India, while it is grown in most parts of the country, it is only produced on a very limited scale for use largely as a vegetable.

The term cowpea when loosely used includes the asparagus or yard bean (*Vigna sesquipedalis*), the Indian cowpea (*V. catjang*), and the common cowpea (*V. sinensis*). The first species possesses pods 1 to 3 feet in length, while the pods of the second are only 3 to 5 inches long, and those of the common cowpea 8 to 12 inches long. Of these three the last is the most common.

The common cowpea is a vigorous herbaceous annual, more or less trailing in habit with stems 8 feet or more in length. The leaves are trifoliolate with large cordate leaflets. The flowers are white or pale violet in colour. They are usually self-pollinated but the presence of extra floral nectaries encourages their visitation by insects and thereby cross-pollination. The pods are long and cylindrical and are somewhat constricted between the seeds. The seeds are numerous. They are bean-shaped and are variously spotted with different colours, the common colours being white, brown, green, yellow and mottled.

The root system of the cowpea consists of a well-developed tap root with a considerable number of laterals from the upper part. These spread out horizontally to about 1 to 2 feet. The greater part of the root system is located in the upper 18 inches of soil.

The cowpea requires a fairly warm growing season for its proper development. It may be grown on different types of soil, but will do best on well-drained loam soil.

No attempt has been made in this country to classify cowpeas. The characters which may be used for distinguishing the varieties now grown are: (1) the habit of growth, that is, whether erect, prostrate or bushy; (2) the length of the maturation period, that is, whether early or late; and (3) the character of the pods and seeds.

Some of the most successful varieties of cowpeas now grown in this country are the imported ones, such as "Black eye", "Whippoorwill" and "Groit".

The cowpea in this country is generally grown as *kharif* crop, but in some parts it may also be grown during the *rabi* season. The preparation of the land before sowing is similar to that for green and black gram. The crop is usually sown mixed with such crops as *jowar* and maize, but it may also be grown alone. When sown alone and in lines the amount of seed per acre is from 10 to 15 lbs. but when sown broadcast the seed rate is higher, 20 to 30 lbs. being considered sufficient for one acre. When sown thick, it usually does not require any weeding as the vigorous growth of the plants tends to smother out the weeds. It is for that reason sometimes used as a cover crop in order to suppress the growth of weeds.

If the crop is grown as a vegetable, the pods are picked while still green, and the stems and leaves may be fed either green or dry to cattle. If grown as a green-manuring crop, it should be ploughed under about the time the flowers begin to appear. If grown for seed, the plants are removed, dried and threshed as in the case of other pulses.

Certain diseases have been known to attack this crop. Among those occurring in this country are root rot (*Hypochynus solani*), rust (*Uromyces appendiculatus*), powdery mildew (*Erysiphe polygoni*) and die-back (*Vermicularia capsici*).

#### SOYBEANS

The soybean is undoubtedly a native of eastern Asia. A wild plant closely similar to the soybean, but more or less trailing in habit, has been found in some parts of China. The soybean is at present the most important oilseed crop of China and Japan. It is now cultivated in many other countries of the world such as Argentina, the United States of America, Australia and India, and its popularity in these new countries is growing very rapidly. In India the crop has been grown for a long time by the people of the hilly regions adjacent to the Himalayas, but its cultivation on the plains of India is being popularized as a fodder plant, as a soil-renovating crop, and also as a pulse.

The soybean has had several scientific designations given to it but the name now adopted according to the international rules of botanical nomenclature is *Glycine max.* It is an erect or sub-erect herbaceous annual growing to a height varying from  $1\frac{1}{2}$  to 6 feet. The stems and branches are covered with short hairs. In appearance the plant is usually bushy. The leaves are trifoliolate, the leaflets being fairly large. Some varieties shed their leaves before maturity, whereas others retain them up to the ripening period. The flowers are borne on short axillary racemes, and are either white or purple. The flowers are generally self-pollinated, but cross-pollination may take place under field conditions. The pods are from 1 to  $2\frac{1}{2}$  inches long, each bearing two or more seeds. The pods are usually dark brown in colour and are always covered with short hairs. The seeds vary considerably in shape, size and colour. They may be yellow, green, brown or black. The root system consists of a tap root with a few laterals.



Soybeans may be grown under varying climatic conditions, and may in this respect be compared to cowpeas. They can also grow on all types of soils but prefer loams or clay loams for their proper development. The requirements of the different varieties differ greatly.

The preparation of the soil for the sowing of soybeans is also very similar to that for cowpeas. The seeds may either be sown in lines or broadcast. When sown in lines at a distance of about 2 feet apart it will require about 15 to 20 lbs. to the acre; but when broadcasted for either green-manuring or fodder purposes the amount of seed used per acre is about 30 to 40 lbs.

If grown for fodder the crop is cut when green and fed to cattle. When grown for green manure it is ploughed under when the plants begin to bloom. But when grown for seed purposes, the crop is harvested before the plants are completely dry as most varieties shatter very badly when left too long in the field. After cutting they are brought to a threshing floor and threshed in the same way as other pulses.

#### PEAS OR MATAR

The pea (*Pisum Spp.*) is probably indigenous to the region comprising Italy and south-western Asia extending eastwards to the Himalayas, including Northern India. Two main groups of peas are generally recognized: (1) the garden pea or *gol matar* (*Pisum sativum*), and (2) the field pea or *desi matar* (*Pisum arvense*). The latter is considered by some to be a sub-species of the former. *P. arvense* is also believed to be the older cultivated form whereas *P. sativum* is of quite recent origin. The latter is usually grown in garden as vegetable, but the field pea is commonly grown in this country as a field crop. The character which easily distinguishes them from each other is the colour of the flowers; for the garden pea has white flowers, whereas the field pea has coloured flowers. Only the latter is discussed here.

The field pea (*P. arvense*) is commonly grown as a

field crop in the United Provinces, Bihar, the Central Provinces, Bombay, the Punjab and Orissa.

The plant is semi-erect, but when a support is available it has a tendency to climb. The stems grow to a height of about two to three feet. It is much less vigorous than the garden pea. The leaves are pinnately compound, with one to three pairs of leaflets and one or more pairs of tendrils. The stipules are prominent and leaf-like. The inflorescence is an axillary raceme. The flowers of the field pea are smaller than those of the garden pea, and are coloured, the colour of the standard being pale lilac, the wings purplish, and the keel yellowish white. Self-fertilization is common, but cross-fertilization may also occur. The seeds of the field pea are marbled and compressed, and are, in that respect, different from those of the garden peas which are large, globose and white.

The field pea is grown almost exclusively as a cold season crop in Northern India. It is generally grown on heavy types of soil such as loams and clay loams. The soil is prepared as in the case of gram and other *rabi* crops. It is sometimes sown mixed with *rabi* cereals such as wheat and barley. When sown alone, it is generally broadcasted at the rate of 60 to 80 lbs. per acre, and are then covered with soil by planking or harrowing. If sown in October, the crop is usually ready for harvesting about March or April. If the crop is grown for seed, harvesting begins when the seeds are mature. This is done by cutting the plants near the ground. They are then removed to the threshing floor where they are threshed out by bullocks.

#### VETCHLING OR KHESARI

*Khesari* (*Lathyrus sativus*) is indigenous to the region between the Caucasus and Northern India. The crop has been under cultivation from very early times in countries such as India, Egypt and Persia. In India, its cultivation is confined mostly to Bombay, the Central Provinces, Bihar, the eastern United Provinces and Sind.

The plant is an annual and is similar in appearance to

the pea. The stems grow to a height of about 2 to 3 feet, but are more or less prostrate unless supports are available. The stems are quadrangular and also possess winged-margins. The leaves are pinnate with only a pair of narrow lanceolate leaflets and tendrils at the tip. The flowers are solitary, arranged in axillary racemes. The individual flowers possess long peduncles. The colour of the flowers varies in different types, being white, blue, red or pink. Self-fertilization of the flowers is the normal procedure, but cross-fertilization is also brought about by bees and other insects which visit them. The pods are four-to-five seeded, and may or may not possess red markings. The seeds are wedge-shaped and may be yellow, brown or variously speckled. It is generally believed that seeds of *khesari* cause a disease known as lathyrism, but recent work has shown that this disease is not caused by *khesari* but by seeds of a vetch known as *akra* (*Vicia sativa*), a weed, the seeds of which are very similar in appearance to *khesari* and are often mixed with it.

The crop is grown in this country during the cold season, and when the soil is too dry for other *rabi* seed crops. It also is commonly sown on heavier soils, although it does fairly well on the lighter soils also.

The Indian *khesaris* have been classified by Mrs. Howard and Rahman Khan into fifty-six different types. The main basis of the classification was the colour of the flowers, the presence or absence of markings on the pods, the size of the seeds and the colour of the seeds.

The preparation of the land for sowing consists in ploughing the land two or three times. The seeds are planted in lines about one foot apart at the rate of about 35 to 40 lbs. per acre. The seeds are then covered with soil by planking or harrowing. Before the plants are fully ripe they are cut and removed to the threshing floor and stacked for about a week until they are dry. When dry, they are threshed by bullocks in the usual way, and cleaned.

## MOTH BEAN

The *moth* bean (*Phaseolus aconitifolius*) is probably indigenous to India, as wild plants occur all over the country, from Ceylon to the Himalayas. The bean is now grown in other parts of the world such as in China and the United States of America. In India it is mainly grown in the Bombay Presidency, the United Provinces, the Punjab and Rajputana.

The plant is a herbaceous creeping annual which spreads on the soil, forming a mat-like covering. This mat-like character has given it the name of mat-bean in the United States of America. The stems grown to a height of about a foot only with a spread of about two to three feet around the base. The branches are numerous and viny, the lower ones lying flat on the ground. The stems as well as the branches are covered with numerous hairs. The leaves are made up of three leaflets, each leaflet being divided into 3 to 5 very narrow segments. The leaves are therefore similar in appearance to those of the aconite plant, a poisonous weed. Hence the plant has sometimes been called the aconite-leaved bean. The flowers are in a cluster with a long peduncle, making them appear above the leaves. But the individual flower pedicels are very short. Self-pollination is the common procedure, but cross-fertilization may occur under natural conditions. The fruit is a pod 1 to 2 inches long, and the seeds are more or less cylindrical with rounded ends.

The crop is usually grown during the *kharif* season and is very resistant to drought. Heavy rain is detrimental to it. It is grown on light and poor soils and is also commonly grown mixed with *bajra*.

The preparation of the soil for the sowing of this crop is very haphazard, and the seed is sown broadcast at the rate of about 10 lbs. per acre. If the crop is grown for fodder, it is cut when the pods have been formed; but if grown for seed, the crop is harvested when the pods are

ripe. The crop is cut with sickles, removed to the thrashing floor, and threshed and cleaned in the usual way.

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## CHAPTER XVIII

### MINOR OIL-SEEDS

In this chapter are included certain crops which are cultivated usually for the oil which is extracted from their seeds. These include the four mustard crops, namely, *sarson*, *rai*, *toria* and *seoba*; and castor, safflower and niger.

#### MUSTARD CROPS

Of the many mustard crops that are in cultivation in different parts of the world, *sarson*, *rai*, *toria* and *seoba* are the most commonly cultivated in India. The first three are probably of European origin, whereas the last is believed to have originated in Africa. These mustards are cultivated in many parts of India, but are more extensively grown in the northern parts of the country than in the south.

*Rai* (*Brassica juncea*) is probably the most common of all the cultivated mustards of India. The plant is a tall, erect, herbaceous annual, 3 to 5 feet in height, and much branched. The leaves are not dilated at the base and not clasping, as in the case of the other mustards, but are stalked and pinnatifid. The inflorescence is a terminal raceme. The fruits are slender and only 1 to 2 inches long, with a beak about  $\frac{1}{3}$  the length of the pod. The seeds are small, and dark or reddish brown in colour.

*Sarson* (*Brassica campestris* L. var. *Sarson*) is also commonly cultivated in this country. The plant is usually shorter than *rai*. It is easily distinguished from the latter by the character of the leaves, which in *sarson* partially clasp the stem. The fruits also are thicker than those of *rai*, and are laterally compressed, with a beak  $\frac{1}{3}$  to  $\frac{1}{2}$  their

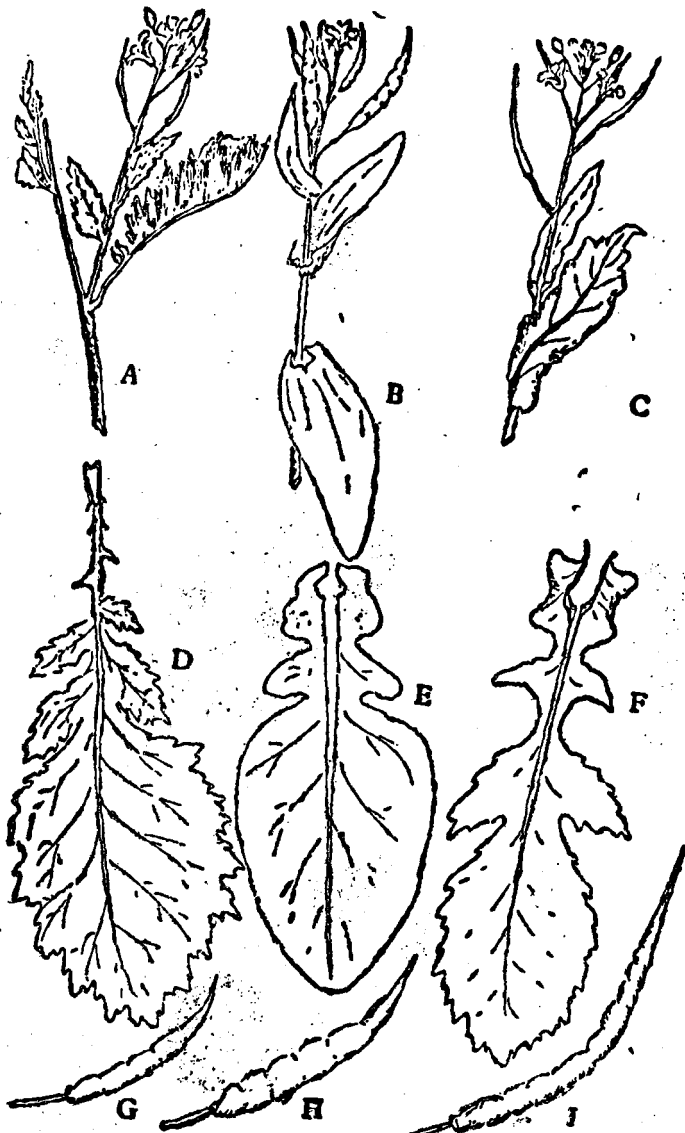


Figure 14

A, A portion of the stem of rai; B, of tara-mira; C, of sarson.  
 D, A leaf of rai; E, of tara-mira; and F, of sarson.  
 G, a fruit of rai; H, of tara-mira; and I, of sarson  
 (Drawn by J. C. Borpuzati).

length. The seeds are either yellow or reddish brown. The seed coat is smooth which also distinguishes it from *rai*, the seeds of which possess rough seed-coats.

*Toria* or *rabe* (*Brassica napus* var. *dichotoma*) is the mustard more commonly cultivated in the Punjab. The plant is more vigorous and more hardy than *rai* or *sarson*. It grows to a height of 4 to 6 feet. The leaves are more or less clasping, pinnatifid and lanceolate.

The following key (adapted from Duthie and Fuller) may be used in the identification of the above three mustards.

- A. Leaves usually hispid, stalked or the upper ones sessile, not auricled and therefore not clasping the stem; fruits slender, more or less constricted. Seeds small, dark brown or reddish brown, distinctly reticulated.....*Brassica juncea* (*rai*).
- AA. Leaves usually glaucous (*i.e.*, not hispid), auricled and more or less clasping the stem; seeds yellow or brown.
  - B. Racemes few-flowered; sepals erect; fruits thick, not constricted; seeds large.....*Brassica campestris*, var. *sarson* (*Sarson*).
  - BB. Racemes many-flowered; sepals spreading; thickness of fruits intermediate, somewhat constricted; seeds brown or reddish brown, rather large, with minute wrinkles.....*Brassica napus*, var. *dichotoma* (*Toria*).

*Seoha* or *tara-mira* (*Eruca sativa*) is a more or less herbaceous annual, about 2 or 4 feet high. The stems are solid and are covered with stiff hairs. The leaves are stalked and are from 6 to 12 inches long. The inflorescence is a raceme. The petals are distinctly clawed. The flowers are extensively cross-pollinated; and it is believed that they are self-sterile. The seeds or ovules are in a double row or series in each compartment of the fruit, a character which distinguishes it from the brassicas, in which the seeds or ovules are in a single row or series in each compartment of the fruit. The fruits are also shorter and rather stoutish.



The oil content of the seeds of these various mustards is somewhat as follows:—

<i>Rai</i> ( <i>Brassica juncea</i> ).. .. .	21 to 28	per cent.
<i>Sarson</i> ( <i>Brassica campestris</i> var. <i>sarson</i> ) .. .. .	33	” ”
<i>Toria</i> ( <i>Brassica napus</i> var. <i>dichotoma</i> ).. .. .	33	” ”
<i>Seoha</i> ( <i>Eruca sativa</i> ) .. .. .	12 to 25	” ”

These mustards are cool-season crops and are therefore grown in the *rabi* season. They are grown on a very large variety of soils.

The mustards are usually sown mixed with other crops such as wheat, gram or barley; but in some cases they may be sown alone as in the case of *toria* in the Punjab. Sometimes *sarson* is also sown in small plots for use as a vegetable (pot-herb). The preparation of the land for the sowing of mustard crops is generally that for the crop with which it is associated.

Sometimes these mustards are cut green and fed to cattle. But when grown for seed, the plants are cut by hand with a sickle, when mature. They are then dried and threshed.

The mustard crops are subject to the attack of certain fungous diseases, such as white rust (*Cystopus candidus*), downy mildew (*Peronespora parasitica*), and blight (*Alternaria Brassicae*). White rust has been found to occur in *seoha* or *tara-mira* and a few other related plants. The disease appears as a white crustation on the leaves and may cause the thickening and swelling of the stems as well as of the floral organs. Downy mildew has been found to occur in all these mustards and also on some other related plants. This also causes an abnormal deformity of the stems but usually not of the flowers. The disease more commonly appears on the undersurface of the leaf as whitish spots. Blight attacks all the green parts of the plants, but more especially the fruit. The disease appears as small brown or blackish spots which first form on the leaves but later spread to the fruit.

The worst enemies of the mustard crops are the aphides, especially on the late crop. These small greenish and soft-bodied insects suck out the juice from all parts of the plant and thus sometimes almost completely destroy the crop. These insects are known to be controlled in nature by other insects such as the lady-bird beetles. They may, however, be controlled to some extent by sowing the crop early, as the second or third brood may be produced in the early crop, which may attack the crop sown later.

### CASTOR

The castor plant (*Ricinus communis*), a member of the *Euphorbiaceae* family, is probably a native of Africa. It is now grown throughout all tropical and sub-tropical countries. In India, it is grown almost all over the country, the cultivation of the crop being not confined to the plains but also grown at higher elevations. The following table will show its distribution in India according to provinces and States.

TABLE 18

Showing the Distribution of Castor in India

Provinces and States	Area in thousand acres in		Production in thousand tons of castor seed in	
	1937-38	1940-41	1937-38	1940-41
Hyderabad .. ..	520	673	40	45
Madras .. ..	247	267	22	27
Bombay (including States) .. ..	89	41†	13	6†
Bihar .. ..	34	33	5	4
C. P. and Berar ..	32	29	6	5
Mysore .. ..	96	101	5	5
Baroda .. ..	88	85	7	7
United Provinces ..	13	11	4	4
Sind .. ..	7	2	2	5
Orissa .. ..	20	16	2	..

† Native States, not included.

The castor plant is a shrub or small tree growing to a height of about 10 to 15 feet. Its branching habit is somewhat different in different varieties. The stems and branches are glaucous and either red or green or with shades of both, and are hollow. The leaves are petioled (occasionally they are sessile near the base), alternate, peltate and green with a red tinge. The young leaves are, however, more reddish in colour. There are usually 8 to 10 lobes on a leaf. The lobes are usually fairly broad, but laciniate ones as well as intermediates also occur. The inflorescence consists of a raceme made up of unisexual flowers, the females occurring at the top and the males at the bottom. The flowers are wind-pollinated. In order to prevent cross-pollination between varieties, it is desirable to plant them at a distance, at least 40 yards apart. The fruit is a capsule made up of several compartments. Two sizes of seeds are generally recognized, large and small. The quantity of oil in the best varieties is from 54 to 56 per cent in the whole (unhulled) dry seed. The amount of oil in the seed depends more on the degree of maturity than on any other factor. It has also been found that the oil content is higher in a warmer climate.

The castor plant in warmer regions is a perennial, but at higher altitudes and in colder regions it is an annual. It is grown in most types of soil, but thrives best in loams. The plant is also considered to be very tolerant of drought, but does not tolerate standing water, and is very susceptible to frost.

No attempt has been made to classify this crop in detail, but it is generally known that it contains at least two different groups, the small-seeded and the large-seeded. The former are early-maturing whereas the latter are late-maturing. Some investigators are of opinion that the small-seeded varieties contain a higher oil content than the large-seeded ones. It is also the general opinion that the small-seeded varieties possess oil of higher quality which is used for medicinal purposes, whereas the large

seeded types yield the best ordinary lubricating lighting oils.

The crop is usually cultivated on the edges of fields, but occasionally it is sown mixed with such crops as the pigeon pea and *sem* (*Dolichos lablab*). It is very seldom grown alone. The method of preparation of the seed-bed is the same as that for the crop with which it is associated. In Northern India the crop is generally sown in the beginning of the rains, but in other parts of the country it may be sown as a *rabi* crop. When sown as a *kharif* crop in Northern India the land is ploughed two or three times at the beginning of the rains, and the seeds are sown in rows about 4 to 6 feet apart either by dibbling or by dropping behind the plough. The plants are then thinned by removing the weakest ones. This may have to be done more than once, until the plants are left 3 to 4 feet apart. The crop may require watering if the rains are insufficient, and one or two weedings during the whole period of growth. The crop takes about 10 months to reach maturity.

The harvesting of the crop consists in picking the mature capsules (fruits) by hand. The picking may continue for one or two months. In some varieties the capsules dehisce (open) and in some they are indehiscent. The indehiscent types are collected and stacked and covered with a cloth or straw. After a few days the capsules are exposed to the sun and on drying the shells split open. If they do not open they are beaten with a wooden mallet until the seed separates from the shell. The seeds are then dried and stored until ready for sale. From the seeds the oil is extracted which is used extensively for medicinal purposes and as an illuminant. More recently the demand for the oil has extended, for use in internal combustion engines and the lubrication of aeroplanes and airships.

The leaves of this plant are sometimes used for rearing *eri* silkworms from which the *endi* or Assam silk is manufactured.

The castor plant is subject to the attack of several fungous diseases and insect pests. The most common of the fungous diseases in this country, is known as the seedling blight (*Phytophthora parasitica*, Dastur). This disease, while it commonly occurs in the seedling stage, also attacks the leaves of older plants. The disease in the early stages attacks the young cotyledons, and later spreads to the stalk causing the leaf to droop and rot. In the older plants the attack is more localized, being restricted to the leaf. The leaf spots are yellow and later turn brown.

Another fungous disease which attacks the crop is known as rust caused by the fungus *Melampsorella Ricini*. This disease has been found to occur in the Bombay Presidency and in the Central Provinces. Still another fungous disease which attacks this crop is known as leaf spot (*Cercosporina ricinella*). This appears as spots on the leaves, the centre of the spot being pale brown, which changes to greyish white and is surrounded by a deep brown band.

A new disease has been reported from the United Provinces, caused by *Botrytis* sp. This disease attacks the plants and destroys the fruiting racemes at the early stages of growth.

The castor plant is also attacked by a number of insect pests, the most common of which are a stem-borer and seed-eating caterpillar (*Dichorocis punctiferalis*), a mealy bug which sucks the sap out of the leaves and which is known as *Aleurodes ricini*, the smooth caterpillar (*Ophiusa melicerti*), the hairy caterpillar (*Trabala rishnu*), and the spiny castor caterpillar (*Ergolis merione*), the last three being leaf-eating caterpillars.

#### SAFFLOWER

Safflower or *kusum*, according to De Candolle, is probably a native of Arabia. More recently Russian investigators expressed the opinion that perhaps the cultivated forms of safflower had originated in two centres. One centre is Abyssinia from which it spread into Egypt,

and another centre is in Afghanistan whence it spread into India and the neighbouring countries. But the Egyptian types are more or less uniform, the Indian types are very variable, due probably to the wide climatic differences which prevail in this country.

Its cultivation to-day is mainly in Egypt, south-west Asia, some of the Mediterranean countries, and India. In this country it has been cultivated from very early times, and is grown in almost all the provinces. But the acreage devoted to this crop in this country is declining, probably due to the competition of the chemical industries.

Safflower (*Carthamus tinctorius*) varies greatly in height, the dwarf types being about one and a half feet tall, and the taller forms being about  $2\frac{1}{2}$  to 3 feet. The plant is glabrous, thistle-like, and much-branched near the top. The leaves are sessile, oblong and lanceolate, but differ in different varieties in the degree of sharpness of the apex, the serration of the margin and the number and size of the spines. The inflorescence is a capitulum or head, more or less typical of the sunflower family (*Compositae*) to which it belongs. The inflorescence is subtended with the involucre bracts which may be spinose or entire. The character of the involucre is believed to be different in the oil-yielding and the dye-yielding forms. The spinose bracts are believed to be associated with the oil-yielding forms, whereas the dye-yielding forms are mostly entire. The colour of the flowers varies from light yellow to orange or red. Yellow colour is usually associated with the oil-yielding forms, and the orange or reddish colour is associated with the dye-yielding forms, these colours probably showing the presence of carthamine. The flowers may be self- or cross-pollinated under natural conditions; selfing, however, is believed to be more common than crossing. The seed varies in size, depending on the influence of the environment and the position of the seed on the capitulum. The percentage of fat in the seeds varies with the different varieties, from 20 to 30 per cent.

Safflower is considered to be a drought-resistant crop, and is therefore grown in this country in poor sandy soils, usually as a border crop for barley, gram, tobacco, wheat, etc. The plant, however, does better in rich loams which are retentive of moisture.

An attempt to classify the Indian safflowers was first made by Howard and his colleagues in 1915. More recently (1935) Sabnis and Phatak have revised the previous classification and have added 29 new types bringing up the total of Indian types to 63. Their classification is based mainly on the character of the bracts, that is, whether spinose or spineless; the shape of the outer bracts; the character and colour of the inner bracts; the colour of the florets; and growth habit of the plants.

The Russian worker, Kupzow, in 1932, attempted to classify the safflowers collected from different parts of the world. In his classification, he divided the safflowers into 21 different ecotypes which together make up two different groups, the eastern and the western. A reference to this work is given at the end of this chapter.

Safflower is sown in this country with *rabi* crops, in most cases on the edges of fields to protect the crops from predaceous animals. When sown alone the seeds are either broadcasted or drilled. The amount of seed per acre when sown alone is about 16 lbs. When the plants have developed a central flowering head, the tip is nipped, as this is believed to encourage the development of lateral shoots and consequently increase flowering.

When the crop is grown for dye, the petals are collected every two or three days when the bright colour is fully developed. Any delay in collecting will result in the loss of dye. Rain during the flowering period is also very harmful as it washes the colouring matter out of the flowers. The immature seeds are left on the plant and allowed to ripen, thus producing a supplementary crop.

When the crop is grown for oil, the petals may or may not be collected, and when the seeds are ripe, the plants are cut, and the seeds are threshed in the usual way.

From the seeds the oil is extracted, which is used for cooking as well as for adulterating ghee.

A leaf-spot disease of safflower caused by *Cercospora carthami*, Nov. Sp. has been reported to occur on the Coimbatore Central Farm, but is not known to occur anywhere else in India.

#### NIGER OR RAMTIL

Niger or *ramtil* (*Guizotia abyssinica*) is probably a native of Africa, but is grown in some parts of India, especially in the Bombay Deccan and the Madras Presidency, as an oil-seed crop. It is also grown here and there in the provinces of Bihar, Orissa and the States of Mysore and Hyderabad.

The plant is a member of the sunflower family or *Compositae*. It is an erect herbaceous annual, about 3 to 5 feet high, and much-branched, most of the branches extending almost to the top of the plant. The leaves are sessile, partially clasping the stem, the shape of the leaf being ovate-lanceolate. The inflorescence is a capitulum or "head" typical of the *Compositae* family and about  $\frac{1}{2}$  to 1 inch in diameter. The colour of the flowers is yellow. The mature seeds are small and black in colour, the number of seeds in each head being about 20 or more.

Niger is a sun-loving plant and requires a good deal of warmth for its proper development. It prefers light sandy soil, but requires moisture during its period of growth. In this country it is usually grown during the *kharif* season.

No attempt has been made to classify this crop, but general field observations would indicate that the nigers grown in this country may be classified into "early" and "late," according to the length of their growing season.

The preparation of the land for the sowing of the seed is very simple, consisting of one or two ploughings followed by planking. The seeds are usually sown broadcast at the rate of about 10 lbs. per acre. When sown in lines the seed rate is usually less, being about 5 lbs. per



acre, the distance between rows being about 14 inches. The crop usually takes about three to four months to reach maturity.

When the crop is ripe, the plants are cut near the root and stacked for about a week. The crop is then spread out and dried in the sun for two or three days and when quite dry the seeds are threshed, and separated from the other materials, by winnowing. The oil extracted from the seeds is used for cooking purposes and for adulterating more valuable oils.

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## CHAPTER XIX

### FODDER CROPS

The subject of fodder crops is growing very rapidly in importance during recent years. The reasons for this are several. One of the reasons is the development of the dairy industry in the country, demanding that more attention be given to the question of better fodder crops. Another reason which may account for the growing importance of fodder crops in this country is the reduction in the pasturelands available for general grazing. Also, the general improvement in agriculture, such as the evolution of better varieties of crops, the use of better implements, and in short, the general improvement in cultural methods, demands more and better animal power. Lastly, an increasing knowledge of what constitutes good nutrition both for human beings and for animals, which has led to an increasing use of milk by the former and the use of more palatable and nutritious food for the latter, is also responsible to some extent, for the interest in, and search for, more nutritive fodders. For these and other reasons, the subject of fodder crops is one of enormous agricultural importance in this country.

Most of the fodder crops fall into two botanical groups: (1) the grasses (that is, members of the gramineae family), and (2) the legumes (that is, members of the Leguminosae family). The following are some of the most important fodder grasses grown in this country: (1) Napier or elephant grass, (2) Guinea grass, (3) oats, and (4) *dub* or *bariali* grass, etc. Among the legumes commonly used for fodder purposes, the following are important: (1) lucerne, (2) clovers and (3) *guara*.

## FODDER GRASSES

*Napier or elephant grass* (*Pennisetum purpureum*, Schum)—This plant is indigenous to Central Africa where it is found growing extensively in the high grass savannas of that region. According to Bews and Phillips, the elephant and Napier grasses are two closely related varieties of *Pennisetum purpureum*, but differ in minor characters. The plant seems to have been used extensively as a fodder for the first time in Rhodesia. It was probably introduced into this country about the year 1915. Since then it has spread rapidly to different parts of India and is being grown mostly in Government experimental and demonstration, and private dairy farms.

Napier or elephant grass is a tall, perennial grass growing to a height of about 6 to 10 feet. The plant tillers profusely, the number of tillers at the end of the first year being about twenty, and the clump increases in number of tillers as well as in size year after year. The tillers are somewhat obliquely erect. The lower part of the stem is usually smooth, but the portion of the stem near the top is usually hairy and is covered with a bloom. The leaves are typical of the grasses. The leaf-sheath clasps the stem and is generally smooth, but may sometimes be somewhat hairy. The leaf-blade is linear and is about two to three feet long. The inflorescence is a dense spike about 6 to 12 inches long. The seeds are not known to develop to maturity.

As no mature seeds are produced, the plant is always propagated vegetatively. Rhizomes, cuttings and rooted slips are all used for the propagation of this crop. But rooted slips are known to give the best and quickest results. The slips are planted in lines three to four feet apart and at a distance of two to three feet apart in the lines. The crop is ready for the first cutting in about four months, and successive cuttings after that at intervals of about a month depending on the water supply and season of the year. The crop responds very readily to irrigation but can stand

drought fairly well. It is, however, very susceptible to frost. The crop does best under irrigation. Under such conditions it will easily yield about 200 maunds per acre in one cutting. Hence the average yield of green fodder in a year with an average of about 10 cuttings is about 2,000 maunds. However, yields as much as 4,000 to 5,000 maunds per acre have been reported. The grass is usually fed green to cattle immediately after cutting, but it is known to make a fairly good silage.

*Gunea grass* (*Panicum maximum* or *P. jumentorum*)— This grass is indigenous to Africa, whence it was introduced to Jamaica and other parts of the world. From Jamaica it was introduced into India about the end of the eighteenth century. Since then it has been recommended as a fodder grass for most parts of India.

The grass is a perennial growing to a height of about 4 to 6 feet or more, especially if it is allowed to grow until the inflorescence has developed on the apex of the plant. The plant, like Napier grass, tillers freely, producing from twenty to thirty tillers in the course of one year. The tillers are more or less erect, but the outer ones are more oblique, especially near the base. The stalks are not so thick as in the Napier grass, but are usually larger than a lead pencil. The leaves are not so broad as those of Napier grass. They are also coarser in texture. However, there is a considerable variation in the width of the leaves of this grass in the different ecotypes, that is, strains or varieties coming from different geographical regions; some ecotypes possessing leaves as broad as those of maize. The inflorescence is a loose panicle, the longer branches being those towards the bottom of the inflorescence. The seeds are readily shattered so that it is difficult to obtain mature seeds. Some, however, may be collected if the panicle is removed before the seeds are mature, and cured in the shade.

The plant grows well in the warm, tropical climate of this country. Although the plant is fairly drought-resistant, it will do best in places where a fairly large amount

of moisture is available in the soil. The crop, however, will not do well in water-logged areas. During the low temperatures which prevail in Northern India during the winter, the plant stops growing and lies dormant, but with the approach of the warm weather it again grows rapidly if sufficient moisture is available. It is also easily damaged by frost. While it may be grown in almost all types of soil, it will do best in light to medium loams.

The crop may be propagated by seed but is more commonly grown from root-slips or setts. These are usually planted in lines about three feet apart and about 2 feet apart in the lines. The root-slips or setts are planted on the edges of large ridges. Irrigation water is allowed to flow in the furrows between the ridges. In most parts of India, irrigation water is necessary if the crop is to be grown economically and commercially.

The crop once planted will last for several years. It is, however, advisable to break up the clumps after three or four years and to replant the setts after heavily manuring the soil. It would, however, be more advantageous to plant the crop on new land if available.

The crop is generally cut while it is quite green and tender before the stems get coarse and tough. The oftener the crop is cut the finer and better will be the fodder. The number of cuttings obtainable in one year varies from 8 to 10, and the yield of green fodder per cutting is about 150 to 175 maunds per acre. Therefore the yield of green fodder per acre per year may vary from 1,200 maunds to 1,750 maunds.

*Oats (Avena sp.)*—The primary centre of cultivated oats, according to Malzew, a Russian investigator, is probably the western Mediterranean region, that is, the region round Mount Atlas in Africa, and the country round the Pyrenees. All the wild and cultivated oats of the world fall into three groups according to the number of chromosomes, the diploids with 14 chromosomes, the tetraploids with 28 and the hexaploids with 42. *Avena sterilis*, according to Malzew, is one with 42 chromosomes. *A. sativa*

also possesses 42 chromosomes but is believed to have originated independently from the wild oat, *A. fatua*, and not from *A. sterilis*.

Investigations made by Bose at Pusa seem to show that the Indian oat is *Avena byzantina* of the group *A. sterilis* and is not the common cultivated oat, *A. Sativa*. *A. sterilis*, has its secondary origin, according to Malzew, in the Pamirs.

Oats have now become a crop of some importance in several parts of Northern India, as a fodder crop, especially on the Government military farms. But it is occasionally grown as a grain crop in some parts of the Punjab and the United Provinces adjacent to Delhi.

The oat is an annual plant and is very similar to wheat and barley. But the stems are usually larger and softer than those of wheat and barley. The plant also usually tillers more freely than either wheat or barley and is therefore, somewhat bunch-like in appearance. The leaves are also broader and more abundant than in wheat or barley. In oats the auricles are absent, a character which distinguishes it from wheat and barley.

The inflorescence, unlike that of wheat and barley, is a loose panicle. The branching of the inflorescence decreases from the base of the panicle upwards and usually spreads in all directions. These branches, however, may be upright or drooping, and in some varieties may appear to turn in one direction only. The flowers are, as a rule, self-pollinated, but cross-fertilization sometimes takes place under natural conditions. The root system of oats is very similar to that of wheat. The mass of the roots are confined to the first two feet of soil, but certain roots may penetrate to a depth of about 4 feet.

Oats is a cool-season crop and its growth in this country is confined largely to the plains of Northern India. It does best on heavy soils such as loams and clay loams.

The method of growing this crop is very similar to that of the small grain cereals such as wheat or barley.

Two varieties of oats evolved at Pusa, known as B. S. 1 and B. S. 2 are considered to be high-yielding and also resistant to drought and diseases.

*Dub or hariali grass (Cynodon dactylon.)* This plant has been dealt with in a previous chapter under weeds. But while it is a serious weed in some places, it is also the best known of all the fodder grasses in India, as it grows in all parts of the country and is fed to cattle as well as to horses and other animals. The grass is indigenous to this country. It is also used extensively as a pasture grass and for lawns. The grass has been introduced into America under the name of Bermuda grass. The grass is propagated chiefly by seed and by rooted cuttings. This is most successfully done during the rainy season. The crop will grow in most types of soil but does not do well on poor soils or on water-logged areas. The crop also does not do well under shade.

*Sudan grass (Andropogon sorghum var. sudanensis)*—This plant is related to *jowar* but is grown only for fodder purposes. The grass is also closely related to Johnson grass (*Sorghum halepense*) which is usually a weed, as it develops rhizomes by which it spreads very rapidly and is thereby difficult to eradicate. Sudan grass is becoming popular in Northern India, where it is usually grown under irrigation. Under these conditions three or four cuttings may be obtained in one year. The grass yields about 200 maunds of green fodder per cutting or 600 to 800 maunds per annum.

*Teosinte or buffalo grass (Euchlaena mexicana)*—This grass is a native of Mexico, and is closely related to maize with which it forms hybrids. The plant is also similar in appearance to maize and grows to a height of about 8 to 12 feet. The plant, however, tillers more freely than maize, and is therefore given more spacing than maize in order to give it a chance to produce abundant tillers. It is grown in this country as a *kharif* crop, and it does fairly well under humid conditions. The crop is cut several times in one season, yielding about 200 to 250 maunds



of very palatable fodder in one season.

Besides the fodder grasses mentioned above, other grasses such as *jowar*, maize and *bajra* are extensively used in this country for fodder purposes. These crops have been dealt with previously in separate chapters.

#### FODDER LEGUMES

*Lucerne or alfalfa (Medicago sativa)*—This is one of the most important leguminous fodder crops of the world. Its origin is probably south-western Asia, that is, Turkey, Persia and Afghanistan. It was probably the earliest crop grown by the peoples of Asia exclusively for fodder purposes. Its cultivation to-day is quite extensive in the drier regions of the world.

The plant is a herbaceous perennial, growing to a height of about two to three feet. The branches arise from a short compact stem at a point, a little above the ground level, known as the "crown". The number of branches may be as many as forty. The leaves are trifoliate, the middle leaflet possessing a short petiole, a character which distinguishes it from a clover leaf. The plant possesses a tap root which penetrates very deeply into the soil, with but few lateral roots. The colour of the flowers is usually purple but sometimes it may be blue, green, or yellow. The flowers under natural conditions, are both self- and cross-pollinated. The fruit is an indehiscent pod coiled two or three times. The seeds possess a very hard seed-coat and therefore they retain their viability for several years. New lucerne seeds do not germinate as satisfactorily as those two or three years old. New lucerne seeds, if scarified, germinate well, the inhibiting cause being believed to be the hard and impermeable seed-coat.

Lucerne can stand a wide range of temperatures. The high temperatures prevailing in Northern India do not seem to damage the crop. The plant can also withstand fairly low temperatures, the degree of resistance being of course different with different varieties. If the high

temperatures are, however, accompanied with high humidity, the plant usually will suffer. It cannot therefore be grown satisfactorily as a perennial crop where the amount of rainfall is beyond 40 inches annually.

Lucerne can also grow well on most types of soil, but it does best on a deep, well-drained loamy soil. It does not do well on soils which are subject to water-logging.

The crop is either sown broadcast or in lines, on ridges. The former practice is usually followed in the semi-arid regions of the country, whereas the latter is the more common practice in regions of high rainfall. The seeds are usually sown in most parts of Northern India during the months of September and October. The amount of seed used per acre is about five seers. Immediately after sowing, the first irrigation is given, and the seed-bed is always kept moist by further irrigations until the seedlings are above the ground. After this, irrigations are given at intervals of about 15 to 20 days during the hot season and at longer intervals during the cold season.

The crop is frequently infested with a number of weeds such as *dub* and *motha* in the hot season and *bathua* in the cold season. These should be carefully removed.

The number of cuttings depends upon the length of the growing season and the amount of water given to the crop during the year. The first cutting is usually taken when the crop is about two to three months old. This is done more especially with the object of getting the plants to develop more branches from the crown. The subsequent cuttings are made when the crop is about  $\frac{1}{4}$  to  $\frac{1}{2}$  in bloom. This is believed to be the period when the leaves are richest in nutritive substances. The number of cuttings obtained in one year is about 6 to 8, and the yield of green fodder per acre per annum is about 600 to 800 maunds. The crop once planted will last for several years. It is, however, not advisable to leave it for more than 4 to 5 years.

*Clovers*—The most common of the clovers now

cultivated for fodder purposes in this country are *berseem* (*Trifolium alexandrinum*), also sometimes known as Egyptian clover, *shaftal* (*Trifolium resupinatum*), also known as Persian clover, and *senji* or Indian clover (*Melilotus parviflora*). Besides these three, burr clover (*Medicago hispida* var., *denticulata*), which commonly occurs in North India as a weed, in wheatfields, and fenugreek (*Trigonella foenum-groecum*) more commonly known in India as *metha* and *methi*, are related plants of the clovers and are, like them, used in certain parts of India as fodder plants.

The following key may be used in order to identify the cultivated clovers and related fodder plants found in this country.

- A. Leaves palmately trifoliate, flowers in a compact head. .... *Trifolium*.
- B. Seeds reddish.....T. *alexandrinum*.
- BB. Seeds brownish and smaller.....T. *resupinatum*.
- AA. Leaves pinnately trifoliate, terminal leaflet stalked.
- B. Pods spiral; flowers in head or short spike...*Medicago*.
- C. Pods toothed.....M. *Hispida*.
- CC. Pods not toothed.....M. *Sativa*.
- BB. Pods straight.
- C. Pods beaked, several inches long.....*Trigonella*.
- CC. Pods not beaked, short.....*Melilotus*.

*Berseem* or Egyptian clover was introduced into India from Egypt probably in 1904. Since then the crop has considerably increased in importance not only as a fodder, but also for the renovation of the soil. This is a herbaceous annual, growing to a height of about 1½ to 2 feet or more. It usually possesses white flowers. Two varieties are generally cultivated in India *Miscavi* and *Khadrawi*.

*Shaftal* or Persian clover is indigenous to Central Asia whence it was introduced into this country. This plant resembles *berseem* in habit and appearance, but it is not as vigorous and has a tendency to lodge. The

stems are hollow and do not grow as tall as *berseem*.

*Senji* or Indian clover, (also sometimes known as bitter clover) is commonly grown in the Punjab and in the North-western districts of the United Provinces. The plant grows to a height of about 1½ feet. This fodder should not be fed alone in large quantities, but should be mixed with *bhusa* or other dry matter, lest it cause tympanitis.

Burr clover is a semi-erect, almost creeping annual. The leaflets often possess white or reddish spots, which disappear with age. This crop is not grown as a cultivated crop in India, although the plant is found growing wild in the United Provinces, the Punjab and other parts of Northern India.

Fenugreek is usually an erect plant with several branches. Two fairly distinct varieties are generally recognized. The tall-growing variety known as *metha* is commonly used as a fodder for cattle, and the dwarf variety known as *methi* is generally used as a condiment or pot-herb. The seeds possess medicinal properties.

All the clovers are usually sown during the cold season, usually in October. The land is prepared as for ordinary *rabi* crops and irrigated, and the seed broadcast. Sometimes the seeds are steeped for 24 hours before sowing. The amount of seed used per acre in the case of *berseem* is about 20 to 30 lbs. but for *shaftal* and for *senji* it is only about 20 lbs. In the Punjab, *senji* seeds are often broadcast in the growing crop of cotton or maize, just prior to the last irrigation given to those crops. In this way, the labour and expense in the preparation of the seed-bed is saved. All the clovers are grown as irrigated crops. Two or more cuttings can be obtained from *berseem* and *shaftal* in one season, most of the cuttings being taken from December to April.

*Guara* (*Cyamopsis psoralioides*)—This plant is grown mainly as a fodder crop but also for green-manuring purposes in several parts of Northern India. The plant is probably indigenous to this country. It is a herbaceous

and erect annual. The stems are simple with relatively few branches. It usually grows to a height of about 3 to 6 feet; but certain varieties have been reported to grow as tall as eight to ten feet. The leaves are trifoliate. The flowers are borne in short axillary racemes. The pods are somewhat flattened and are  $1\frac{1}{2}$  to 2 inches long, each pod bearing about seven seeds. The pods are somewhat erect and are borne in a cluster, hence the plant is also known as the cluster bean. When the pods are tender, they are often used as vegetables. Two varieties of this plant are generally recognized, the giant and the dwarf. The giant variety commonly grown in Gujarat is tall and possesses larger pods and seeds than the common or dwarf variety which is more commonly grown in the Punjab and the United Provinces.

This legume is generally grown as a *kharif* crop in Northern India. It does best on sandy loams and does not do well in the black cotton soil. The seeds are usually broadcast and then covered either with a harrow or a planker, but sometimes they are also sown in lines. In the Punjab, the crop is usually sown alone; but in the United Provinces it is usually mixed with *jowar*. When sown alone the amount of seed used is about 10 lbs. per acre. When the crop is grown for fodder, the plants are cut when in flower or when the pods are beginning to form. When grown for seeds the crop is left until the plants are mature.

*Kulthi (Dolicho biflorus)*—This crop is grown extensively in the Bombay and Madras Presidencies, and to some extent in the hilly regions of the United Provinces, and in Chota Nagpur, the northern districts of Bengal and also in some parts of Assam, and is, like *guara*, grown for both fodder and for green-manuring purposes. This plant is indigenous to this country. The plant is a much-branched annual, the branches intertwining among themselves or with the plants with which the crop is grown. The leaves are trifoliate, the leaflets being ovate and entire. The flowers are borne one to three together in the axils.

of the leaves. The pods are  $1\frac{1}{2}$  to 2 inches long, flat, much recurved and tipped with a persistent style. They contain from five to six, usually variegated, seeds.

The crop does best on light sandy soil, and is extensively grown on the light red stony soils of the Deccan. The preparation of the soil is similar to that for other pulses. The crop, in most parts of the Deccan, can be grown at almost any time of the year, but in Northern India it may be grown either as a catch crop after the *rabi* harvest or as a *kharif* crop. When grown for fodder, the seeds are sown more thickly at the rate of about 25 lbs. per acre. When grown for fodder the crop may be harvested about a month and a half after sowing.

*Minor leguminous fodders*—Besides those mentioned above, there are a number of leguminous plants which are more or less used for fodder purposes. Such are soybeans, peas, Japanese clover (*Lespedeza striata*), groundnut tops, cowpeas, *sem* or hyacinth beans (*Dolichos lablab*), *urd*, *mung*, *moth*, *khesari* and the vetches.

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