GENERAL.

SORGHUMS*

GEORGE M. REED.

The cereals, as wheat, rice, corn, and rye constitute the basic food of most of the world's human population. Although sorghum occupies a minor place among these crops, yet for centuries it has been a staple food plant of certain sections of the Old World. The inhabitants of the Bombay and Madras Presidencies of India, of Northern China, Manchuria and Chosen, of Western Asia (including Syria, Turkestan and Mesopotamia), and of parts of Africa have depended largely upon this cereal for human, as well as animal, sustenance.

CULTIVATION IN THE OLD WORLD.

Northern China and Manchuria.—Quite diverse kinds of sorghum are grown in the different regions of the world. In Northern China and Manchuria a special group, the *kaoliang*, is extensively cultivated. The number of varieties is very great, so that it is possible to find in a single field thirty or forty different kinds which differ in height, time of maturing, colour of seed, and other characters. The grain constitutes the main food of the people, the light coloured varieties being the principal ones used for grinding into flour and making cakes. The varieties with dark coloured grains are less desirable for human food and are used as feed for the farm animals, taking the place held in other countries by oats. The grain is also used for distilling the fiery spirit called "Samshu" so common in North China. The heads, after the removal of the seed, are utilized either for fuel or for the manufacture of brooms—some varieties being better adapted for the latter purpose than others. Also the stalks are used for fuel, for making baskets and mats, for building houses and fences and as poles for beans, cucumbers and yams. Even the roots are dug up and used for fuel.

India.—Sorghum, or *jowar*, as it is commonly called, ranks third among the cultivated crops of India: approximately 25 million acres are grown annually. The crop is first in importance in the Bombay Presidency, where more than one-third of the total area (approximately 8 million acres) devoted to the cultivation of grains is sown to sorghum. Two distinct types of sorghum crops are grown here: the summer crop, or *Kharif* jowar, sown in the spring and harvested in the fall; and the *Rabi* crop, or winter jowar sown in September or October and harvested in the following February or March. Different varieties are utilized in the plantings of Kharif and Rabi jowar Throughout India, the grain of the sorghums is used very largely for human consumption, and the number of varieties grown is very large.

Africa.—Sorghums are widely distributed in Africa and are the staple cereal crop of a large proportion of the native population. The grain is

* This *Leaflet* has been prepared to accompany an educational exhibit of the types of sorghum, prepared by the Brooklyn Botanic Gardens for the High Schools.

used for human food and for the manufacture of fermented drink. Certain types are extensively cultivated in Egypt and in the Barbary States of Northern Africa. In South Africa quite different varieties usually spoken of as *kafir* corn, are found.

Europe.—Broom corn has been cultivated in Italy for about 300 years, and to-day is an important agricultural product in Italy and Hungary. With the exception of broom corn, sorghums have not been extensively grown in Europe, although in the Mediterranean countries some varieties are grown, the seed being used for poultry and stock feed. To a minor extent the grain is also used by the poorer classes in making bread.

INTRODUCTION INTO THE NEW WORLD.

West Indies.—The Sorghums were introduced early into the West Indies from Africa. In Jamaica a variety known as "*Guinea* corn" is grown rather extensively. In Haiti several closely related varieties are grown under the general name of "Petit Mil." The grain is extensively used for human food, as well as for feed for animals.

United States.—Broom corn was apparently the first sorghum to be introduced into the United States, which occurred as early as 1798. During the early part of the last century it was grown more or less widely over the eastern part of the country, but in recent years its production has proceeded westward, and at the present time most of the crop is grown in Illinois, Oklahoma, and adjacent states. Some varieties of sorghum yield a sweet sap which is extracted and made into syrup, and these, the saccharine sorghums, or *Sorgos*, were first introduced into the United States in 1853. At that time a Chinese sorgo, of the Black Amber type, was introduced from France. In 1857, Mr. Leonard Wray, an English planter who had collected a number of saccharine sorghums in South Africa, introduced his varieties into this country. Previous to 1880, several types of grain sorghums were also introduced. In 1876, two varieties of kafir were exhibited by the Orange River Colony at the Centennial Exposition in Philadelphia. About the same time varieties of durra were introduced from Northern Africa. A number of kaoliangs were also brought in from China and Manchuria. In the early part of the twentieth century *Feterita and Sudan grass* were introduced from Sudan. Some additional varieties of kaoliang were brought in from North-eastern Asia, as well as additional varieties of kafir from South Africa.

The sorghums at the present time have a very great value in American agriculture. The grain sorghums are well adapted to the southern Great Plains area, including Western Kanas, Western Oklahoma, Northwestern Texas, Eastern Colorado and Eastern New Mexico. In this general region they have shown themselves a much more reliable crop than corn. It is an interesting fact that, with the exception of broom corn and the Black Amber types of sorgo, nearly all of our valuable sorghums have been introduced from Africa. The sorghums of India and the kaoliangs from Northern China and Manchuria have not proved to be particularly well adapted to our climatic conditions.

DISTRIBUTION AND BOTANICAL CHARACTERISTICS.

All the sorghums are regarded as belonging to a single species of the grass family—*Holcus sorghum* L. (*Andropogon sorghum* (L) Brot.). The

wild forms of the species, which are closely related to Sudan grass, Tunis grass, etc., are widely distributed in Central and South Africa, Egypt, Madagascar and neighbouring islands. These are annual plants without root-stocks and are differentiated into a number of distinct races or sub-species. Forms of these grass sorghums growing wild in Africa are nearly as large and coarse as some of the cultivated types, with which they readily hybridize.

The number of cultivated varieties of sorghums which are grown in the various parts of the world is extremely large. A relatively small number of these have been introduced into the United States, and as already noted most of the useful ones have been brought in from Africa. It is difficult when the varieties from all parts of the world are taken into account to adequately classify them, as the dividing lines between the different groups are very indefinite. They appear to hybridize with one another very readily so that new forms are constantly originating.

In general appearance the sorghums somewhat resemble corn or maize The flowers, however, are perfect and the grain is borne in compact or loose panicles at the upper end of the stalk. The flowers appear to be generally self-pollinated, but cross pollination occurs so frequently that hybrids are constantly arising when two or more varieties are grown adjacent to each other. The sorghums are grown as a tillage crop and planted and cultivated in the same general manner as corn.

AGRONOMIC GROUPS OF SORGHUM IN THE UNITED STATES

The sorghums grown in the United States may be grouped into four agronomic classes:—

1. *Broom corn.* This is grown primarily for the "brush" used in the manufacture of brooms.

2. *Grass sorghum.* The most important one is Sudan grass which is grown for forage for stock.

3. *Sorgo.* This group includes the sweet or saccharine sorghums used for the manufacture of syrup; many varieties, however, have proved to be extremely valuable as forage plants for stock, and in recent years large areas have been devoted to their cultivation for this purpose.

4. *Grain sorghum.* This group includes many varieties which are grown primarily for their grain, although the stems and leaves are also used as feed for stock.

BROOM CORN.

Our modern broom corn has probably been derived from some sorghum with a loose open head and is grown primarily for the "brush," which consists of the panicle or branching inflorescence used in the manufacture of brooms. The stems and leaves have some value as stover or fodder for stock. The panicle varies from 15 to 24 inches in length and is umbelliform, with greatly elongated branches and drooping tips. The rachis or main axis is usually less than one-fifth the length of the panicle. The grains are reddish in colour and included within the glumes.

There are at least three distinct varieties of broom corn grown in the United States. These differ mainly in the height of the plant, in the tenacity of the attachment of the peduncle to the upper node of the

stem and the length and texture of the brush. Standard broom corn has been grown for many years. In Western Oklahoma it grows to a height of 8 to 10 feet but under more favourable moisture conditions it reaches a height of 12 to 15 feet. The other varieties of broom corn are much shorter, ranging from 3,5 to 6 feet in height. At the present time dwarf broom corn composes about two-thirds of the total crop in this country, as it is especially well adapted to the climatic conditions of Oklahoma and adjacent regions.

Broom corn is grown in the same general fashion as corn and requires similar methods of tillage. The brush is harvested just after the flowering period and as late as the milk stage of development of the kernel. During this period the natural green colour is developed throughout the branches of the panicle and, if properly cured, the brush is flexible and of the best quality. Immediately after harvesting, the broom corn is threshed by means of a special machine which removes the kernels. It is then usually placed in a specially-built drying shed where it is allowed to cure. After curing it is crated and baled for the market. The weather conditions during the harvesting period and the care taken in harvesting, threshing, curing, crating and baling are very important factors in determining the value of the final product.

The total acreage devoted to broom corn varies greatly from year to year. In 1923 approximately 500,000,000 acres were grown, over half of the acreage being in Oklahoma. The average yield in 1923 was about 278 pounds of brush per acre, and this had an average farm price of about $160 per ton, or about $22 per acre.

GRASS SORGHUM.

There are several varieties of sorghums which have considerable value as grass or hay crops. The most important one is Sudan grass, which was first introduced into the United States in 1909, the grain being received from Director R. Hewison, Department of Agriculture and Lands, Sudan Government, Khartum, Sudan. Some later introductions have also been made, but practically all of the Sudan grass grown in the United States has come from the first importation. In 1918 the value of this crop was estimated at $10,500,000. Sudan grass is an annual, which grows rapidly and produces stems 4 to 6 feet high. It has proved to be a very desirable forage plant in the southern part of the United States and can be successfully grown as far north as Michigan and New York.

SORGO.

The first variety of sorgo, or sweet sorghum, was introduced into the United States from China by way of France. In 1851, some grain was sent to France from the Island of Tsung Ming, but only one grain grew. The resulting plant had a tall slender stem and bore a loose panicle with more or less drooping branches and light brown seeds enveloped by black shiny glumes. Some grain was introduced into the United States in 1853 and, since many of our present forms of Black Amber sorgo show these same characters, it is probable that most of them have originated from this Chinese variety.

However, the majority of our sorgos have come from South Africa. Mr. Leonard Wray, an English sugar planter at Natal, South Africa, procured sixteen varieties which were grown by the various native tribes and called by them "Imphee." Wray brought these varieties to Europe about 1854 and arranged to have them grown in various countries. Fifteen of them were introduced into the United States and in 1857 were grown in Georgia and South Carolina. The original introductions were soon widely distributed over the United States. They hybridized readily and selections were made which resulted in a multiplication of so-called varieties. A large number of names has been recorded for the different sorgos, but the number of really distinct varieties is not very large.

Our American sorgos may conveniently be classed in five groups :

1. *Black Amber sorgo.* This group includes the various varieties of strains developed from the original Chinese importation. For the most part they are early maturing and are characterized by rather slender stems, narrow leaves, and panicles black in general colour, due to the black shiny glumes which almost conceal the reddish yellow grains.

2. *Orange sorgo.* This group can be traced to one of the original Wray introductions from South Africa. The varieties have larger and thicker stems and more abundant leaves than the Black Amber group. The panicles are much heavier and more compact. The glumes are deep red or black at maturity, the reddish yellow seeds projecting between them and giving a lighter general colour to the head as compared with the Amber varieties.

3. *Sumac sorgo.* This variety is also descended from one of Wray's original varieties. It has, however, remained quite true to type. It is a stout, stocky variety, 7 to 10 feet high, with an abundance of large leaves. The panicles are short, thick, cylindric, erect, 6 to 9 inches long, and sometimes spreading more or less at the tip. The pedicles are very short and the seed is quite small; the glumes are shorter than the seed and vary from deep red to black in colour.

4. *Gooseneck sorgo.* This variety is also probably derived from one of the original African varieties. It is very large, growing 10 to 15 feet high, with stem 1·5 to 2 inches in diameter at the base. The heads at maturity are 5 to 9 inches in length and 3 to 5 inches in width and almost black in colour; they are recurved or pendent. Since the variety requires a long growing season it cannot be successfully grown very far north.

5. *Red Amber sorgo.* This variety is a recent importation from Australia and promises to be of great value in California as well as in the Great Plains area. It is characterized by red glumes and is more leafy and has a sweeter juice than the older Black Amber types.

The cultivation of sorgos for the production of sorghum syrup is widely distributed throughout the United States, although the total quantity produced is not very great. In 1923 about 32 million gallons of sorghum syrup were produced. The average yield was about 84 gallons per acre, and the total farm value of the sorghum syrup was over $27,000,000. The five leading states in the commercial production were Kentucky, Mississippi, North Carolina, Georgia and Tennessee. Mostly all the crop is

grown in comparatively small areas on the farms. In many places the syrup is extracted by comparatively crude methods. To some extent the farmers in the community will co-operate and have their syrup manufactured by a central factory which has installed modern machinery and up-to-date methods. The crop is harvested shortly before the seed is ripe, for at this stage there is the maximum amount of sugar. The essential points in the preparation of the syrup are the extraction of the juice from the stems by pressure, and later boiling down and clarifying.

In the southern Great Plains area the sorgos are grown quite extensively as forage for stock, as the juicy stems have proved to be an excellent feed for the farm animals. The crop is handled in practically the same manner as corn. A large proportion of it is made into silage.

GRAIN SORGHUM.

This group of sorghums is grown primarily for the grain, which is extensively used as feed for stock. To some extent the grain is also used for making flour for pancakes and in the preparation of breakfast foods. The kinds grown in the United States may be placed in the following groups: durra, feterita, kafir, milo, kaoliang and shallu.

Durra.—There are two common varieties of durra in the United States: White durra in which the seeds are white and the lemmas are awned, and Brown durra with brown seeds and unawned lemmas. These forms are somewhat closely related to feterita and milo. They are characterized by slender to medium stout, dry pithy stems. The panicles are short, broadly ovate, compact and recurved, although strains with erect heads have been developed. The glumes are greenish white, densely pubescent, and the seeds are very much flattened. The exact origin of our durras is not known, but a variety of sorghum very similar to our White durra is grown extensively by the Kabyles in Algeria. The White durra is also sometimes spoken of as White Egyptian corn and also as Jerusalem corn.

Milo.—The exact origin of our milos is unknown. Soon after 1880 a variety known as "Millo Maize" was grown in South Carolina and Georgia. It was later introduced into Western Texas and the drier sections of adjacent states where it has proved to be a very successful crop, as it is able to produce grain and forage under conditions where corn and other crops fail. The stems of milo are medium in size and pithy. They grow to a height of 5 to 8 feet and bear 8 to 10 rather short narrow leaves. The heads are large, ovoid to oval, compact, and pendent or recurved, although sometimes more or less erect. The glumes are dark brown to black, mostly glabrate and transversely wrinkled. The seeds are large, salmon or white in colour, sometimes flattened, and about one-third enclosed in the glumes. From the original type four distinct varieties differing in height and colour of the seed have been selected. The best general variety is the Dwarf Yellow milo which grows to a height of about 4 to 5 feet.

Feterita.—This sorghum is proving one of our best grain types. It was first obtained in 1901 from Alexandria, Egypt; but it came originally from Sudan, where it is known as Sudan durra. Feterita is quite similar to milo in most of the characters of the stalks and leaves. It averages about 5 feet high, has dark brown to black, pubescent to glabrate, transversely, wrinkled

glumes, unawned lemmas, and erect and nearly oval panicles. The seeds are chalky or bluish white and less flattened than in the durras.

Kaoliang.—The kaoliangs have been introduced from the northern parts of China and Manchuria, and constitute quite a distinct group of grain sorghums. The introduced varieties vary greatly in height, earliness, productiveness and other qualities. Only one variety, the Manchu, has become agriculturally important in the United States, being grown to some extent in South Dakota where its cultivation seems to be increasing. Kaoliangs have a slender, dry, pithy stem; the internodes are usually long and the plant bears 7 to 10 leaves; the panicle is compact. The introduced varieties may be grouped as follows: 1. White kaoliangs, possessing white glumes and white grains; 2. Blackhull kaoliangs distinguished by black glumes and white grains; 3. Brown kaoliangs characterized by brown or reddish-brown glumes and grains; 4. The Blackhull Brown kaoliangs with black glumes and seed of some shade of brown or reddish brown.

Shallu.—About 1890 a variety of shallu was introduced from India by the Louisiana Agricultural Experiment Station under the name of Egyptian wheat. It has been extensively advertised in various parts of the country. It, however, does not possess much value as compared with the other grain sorghums. It has a slender dry stem which grows, 5 to 8 feet tall in the southern Great Plains area. The heads are large, stiff, conical, and pale yellow in colour. The long slender branches of the heads spread and droop at the tips. The young grain is closely enveloped by the greenish-yellow glumes, but as it ripens they turn to a dull brown colour, open widely, and expose the grain. The ripe grains are ovoid, somewhat flattened, and whitish to pale buff in colour.

Kafir.—Six distinct varieties of kafir are more or less extensively grown in the United States. Two of these, White kafir and Red kafir, were introduced from South-Eastern Africa in 1876 when they were exhibited by the Orange Free State at the Philadelphia Exposition. The kafirs vary considerably in size and earliness, and are distinguished by their stout, stocky, semi-juicy stems with short internodes and overlapping leaf sheaths. The leaves are broad, 11 to 16 in number. The panicles are erect and slender. The glumes are shorter than the grain and the lemmas not awned.

One of the best varieties is Blackhull Kafir, distinguished by black glumes and white grains. Recently Sunrise kafir and Dawn kafir have been developed, the original head from which they were selected being collected in the autumn of 1906 in a field of Blackhull kafir. The grain from this head was planted the next season and two selections were made which became the progenitors of Sunrise and Dawn kafir. They both resemble Blackhull kafir in maturing earlier and dwarfer. Dawn kafir is shorter and somewhat earlier than Sunrise. It is possible that both Sunrise and Dawn have been selected from the progeny of a chance hybrid between Blackhull kafir and White kafir, the latter imparting earliness, dwarf stature and shorter peduncles to the progeny. The kafirs are valuable both as grain and forage plants. Much of the crop grown is used for silage.

The general methods of handling the grain sorghums are the same as for corn. They are planted and cultivated by similar machinery. At harvest time the fields are usually cut by a corn harvester and stood in shocks for curing. Later the grain is threshed out by a special machine and the stems and leaves used for forage. In other cases the grower drives through the field with his team and cuts the ripe heads from the standing grain. The stock are later turned into the field and utilize the rest of the plant.

The grain sorghums have proved to be a great boon to the farmers of the southern Great Plains area. They are well adapted to the conditions which prevail in that region where the annual precipitation is low and unevenly distributed throughout the year. In 1923, 5,776,000 acres were devoted to them, the leading states in production being Texas, Kansas and Oklahoma. The average yield of grain was 18·3 bushels per acre and the average price per bushel was $ 94, the total farm value being approximately $ 100,000,000.

SORGHUM SMUTS.

The sorghums have their quota of fungous diseases. The most serious ones appear to be the smuts. The covered kernel smut (*Sphacelotheca sorghi* (Link) Clinton) is apparently co-extensive with the cultivation of sorghums, frequently causing very heavy losses.

In the United States, it is not uncommon to find fields which show 20 to 50 per cent. of the heads destroyed by this disease. The infection of the sorghum plant takes place in the seedling stage from spores adhering to the grain. The infected plants, however, cannot be detected until about the time of heading out; then the enlargement of the ovaries due to the unusual development of the parasite is easily observed. These hypertrophied kernels constitute the smut balls, which contain enormous numbers of dust-like spores. The smut balls are broken in threshing and similar operations and the spores come in contact with the sound grain.

The life history of the parasite causing loose kernel smut (*Sphacelotheca cruenta* (Kuhn) Potter) is somewhat similar to that of the covered smut, but its pathological effects are strikingly different. The infected plants head out earlier than the normal and are noticeably dwarfed in nearly all sorghum varieties; they also show more tillering and branching as compared with the normal. The smut balls are much longer, more slender and cylindric in shape. They break open very readily and permit the distribution of the spores, the rupturing of the membrane occurring even before the smut ball has completely emerged from the glumes. While the loose smut fungus obtains entrance into the host through the young seedling, it has recently been demonstrated that infection can take place in the field either through young panicles or individual flowers from the spores on the early-heading infected plants.

The head smut (*Sorosporium reilianum* (Kuhn) McAlpine) differs from the two kernel smuts in the fact that usually the entire head is more or less completely converted into a mass of smut spores. It is not so common as the covered kernel smut, but in certain localities it is destructive to some varieties of sorghum. It seems to depend for its distribution very largely upon spores in the soil. This smut is also particularly interesting from the act that it occurs on maize as well as on sorghum.

Extensive studies have been made on the resistance of sorghum varieties to the common smuts particularly the covered and loose kernel smuts. The varieties of broom corn, durra kafir and sorgo seem to be quite susceptible. On the other hand, Feterita and the milos have shown a high degree of resistance to both the kernel smuts.

Great improvement has been made in the development of American sorghums. The introduced types were usually very variable, but by careful selection varieties have been secured which are uniform in height, time of maturing, as well as increased yield. Although the sorghums are usually self-pollinated and consequently breed true, yet a considerable amount of cross-pollinated may take place between different varieties grown adjacent to each other. Extensive hybridization is possible within the group, which may be the basis for developing new varieties.

Breeding for smut-resistant types combining various agronomic features offers a fertile field for investigation. The study of the inheritance of smut resistance in crosses involving susceptible and resistant varieties is also a particularly interesting one.

DEVELOPMENT OF AGRICULTURE IN INDIA.*

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The choice of a suitable subject for an address to this Section is becoming an increasingly difficult matter, for I find that my predecessors have dealt with practically every phase of the agricultural problem in India. I was tempted on this account to follow the example of my immediate predecessor and deal with what I may call my own special subject of fibres. This, however, would have required lengthy treatment, which did not seem to be desirable on account of the long programme of papers submitted by members. Therefore, though I know that some repetition is inevitable, I decided to confine myself to a short review of work which has been done, and of the progress which is being made in the improvement of Indian agriculture.

It is well known that many attempts at agricultural improvement in India were made long before the inauguration of the Indian Agricultural Service, and that the record of such attempts goes back beyond the middle of the nineteenth century. There seem to have been periodical impulses towards agricultural progress, but, while nearly all these took the form of organization and propaganda, none culminated in the prosecution of research. The result was that whatever enthusiasm was generated soon died, because there was no one to point the way and to show what was to be done. It was not realized at that time that research and then demonstration must precede propaganda, and in India the general recognition of this as a principle is probably not much older than the present century.

The position at this time is well described by His Excellency Lord

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* Presidential Address at the Agricultural Section of the Indian Science Congress, Benares, 1925.