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# SISAL AND HENEQUEN AS BINDER-TWINE FIBERS.

By H. T. EDWARDS,

*Specialist in Fiber-Plant Production,  
Bureau of Plant Industry.*

## FOOD SUPPLY OF THE UNITED STATES.

THE production, preparation, and distribution of an abundant food supply for the 100,000,000 consumers in this country, with a surplus for export to other countries, is an exceedingly complex industrial problem. It has been demonstrated during the war that the entire world is never far distant from the "bread line." It is essential, primarily, that food be sufficient for the present day and year, but it is essential also that such foresight be used, and such precautions be taken, as will give reasonable assurance of an abundant food supply for the years to come. The needs of the food-producing organization and the requirements of the food-producing machines must be clearly understood. If any defects exist in the organization, or any reasons why the operation of the machines is liable to interruption, it is desirable that these conditions be remedied with the least possible delay.

The food situation of the United States is materially different from that of certain other countries. In China, for instance, a shortage of rice must inevitably be followed by famine. This country has a great variety of food products in general use, and is not absolutely dependent on any one of these products.

Bread, however, is a staple food that is almost universally used throughout this country, and the maintenance of an abundant supply of bread is the one most important feature of our food problem.

## THE GRAIN INDUSTRY.

Half a century ago the small-grain crops—wheat, oats, rye, and barley—were harvested entirely by hand labor. The only implements required were a grain cradle and a

hand rake. The sheaves of grain were bound with bands made from the straw itself. The farmer of that period was independent of the outside world. Hand labor was used in every stage of the operations and production was limited, but the necessary labor was available, and the crops were sufficient to meet the existing demand for food.

The grain producer of to-day is no longer in this independent position. He has become a part of the great food-producing organization. The manufacturers of far-distant cities furnish him machinery; his grain is bound with twine made from fiber that is imported from foreign countries; the jute fields of India provide the material for his grain sacks. With this use of machine methods, the amount of hand labor required is relatively small, and the total production of grain is enormous. It is essential, however, that there be no flaws in the organization, no interruption in the operation of the machines, if our millions are to be fed.

#### THE PLACE OF BINDER TWINE.

During the year 1917 more than 100,000,000 acres were planted in the United States to the small-grain crops, wheat, oats, barley, rye, and rice. The total production of these crops amounted approximately to two and one-half billions of bushels, the greater part of which was harvested with harvesting machines. These machines not only cut the grain, but also bind it in bundles and automatically tie these bundles with binder twine (Pl. XLVIII, fig. 1). If the operation of the harvesting machines is to be continued, the necessary supply of binder twine must be available. To harvest the present annual grain crop of this country, or even a considerable part of it, with hand labor would be a physical impossibility with the amount of farm labor now available.

Fifty years ago binder twine was unknown. At present 200,000,000 pounds of binder twine are required to bind one year's grain crop in the United States, while more than 100,000,000 pounds of American binder twine are used each year in the grain fields of other countries. With the steadily increasing production of grain in the United States, there will necessarily be a corresponding increase in the consumption of binder twine in this country. With the development of grain production in eastern Europe, Manchuria, Aus-

tralia, Argentina, and other countries, and with the more general use of harvesting machinery in these countries there is sure to be a very material increase in the world's total consumption of binder twine.

Inasmuch as grain production is now dependent on the use of harvesting machines, and as the operation of these machines is dependent on the supply of binder twine, it is evident that the supply and the cost of bread are directly affected by the supply and cost of binder twine. It is equally evident that the binder-twine situation is largely determined by the supply and cost of the materials required for the manufacture of this article.

#### BINDER-TWINE FIBER.

Practically all binder twine is made of hard fibers. These fibers include henequen from Yucatan and Campeche; sisal from tropical East Africa, the Bahamas, Java, and the Hawaiian Islands; abacá from the Philippine Islands; and phormium from New Zealand. Some of the soft fibers, such as hemp, jute, and flax, have been used to a limited extent, but these fibers appear to be unsatisfactory for binder twine.

Among hard fibers suitable for the manufacture of binder twine, both abacá and phormium occupy a position of very minor importance. The price of abacá fiber is such as to prevent its extensive use for binder twine when cheaper fibers are available. The total production of phormium is not sufficient to make this fiber important.

Henequen and sisal furnish approximately 90 per cent of the raw material now used in the manufacture of binder twine, and approximately 80 per cent of the world's supply of binder twine is made from Yucatan henequen. If for any reason the production of henequen in Yucatan should decrease materially, the results would be disastrous. Failure to set out new plantations so as to keep up production in future years, which is even now reported in Yucatan, must result in a shortage of supply unless plantations are developed elsewhere. In course of time substitutes for this fiber might be obtained, but the immediate results would be a curtailment in the production of grain and a consequent shortage in the world's supply of bread. Furthermore, if any considerable part of the supply of Yucatan henequen

should be diverted to markets other than those of the United States, the American farmer would either be without binder twine or would be dependent for his supply on the manufacturers of other countries.

The cost of binder twine is also worthy of consideration. With an annual consumption of 300,000,000 pounds of binder-twine fiber; an increase in the cost of this fiber of 1 cent per pound is equivalent to a total increase of \$3,000,000. In September, 1915, the price of Yucatan henequen in the New York market was 5½ cents per pound. In August, 1917, the price had advanced to 19½ cents per pound, an increase of 14 cents per pound, or approximately 270 per cent, within a period of less than two years. With the present consumption of binder-twine fiber in this country, this increase in the cost of henequen fiber is equivalent to an increase of more than \$28,000,000 in the yearly binder-twine bill of the American farmer.

At present the production of 80 per cent of the total available world's supply of a raw product that is indispensable to the grain producer of this country is confined to one small foreign state. It is by no means impossible that either natural or political conditions may arise that will result in a material reduction in the supply of Yucatan henequen.

The existing binder-twine fiber situation is not only unsatisfactory, but also exceedingly dangerous. It is one of the weakest spots in the food-producing organization of the United States.

The situation can be remedied either by using substitutes for henequen in the manufacture of binder twine or by increasing the production of henequen and sisal in countries other than Yucatan. The introduction of substitutes would be a difficult and slow undertaking, but there appears to be no satisfactory reason why the production of both henequen and sisal can not be increased very materially in several countries.

#### GEOGRAPHICAL DISTRIBUTION OF SISAL AND HENEQUEN.

The henequen plant, *Agave fourcroydes*, is native in the Yucatan Peninsula (Pl. XLIX, fig. 1), where it has been cultivated for centuries. During the last 50 years many large henequen plantations have been established in Yucatan.

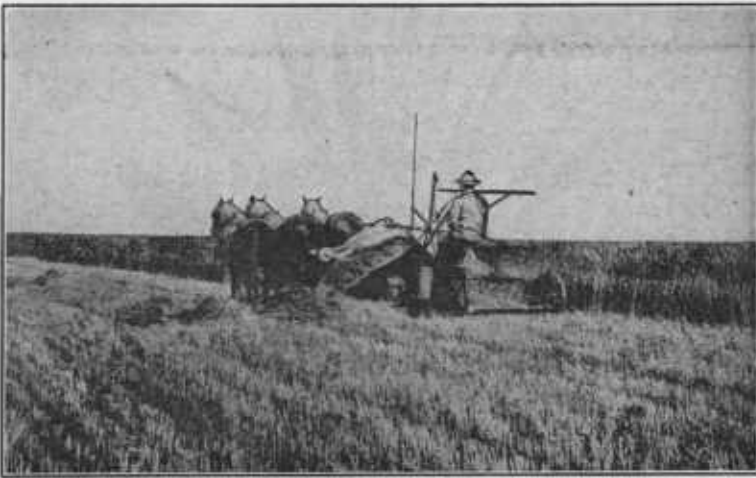


FIG. 1.—SELF-BINDER IN OPERATION.

Grain, cut at the right of the machine, is carried over the elevator to the left, where it is bound in bundles tied with binder twine.

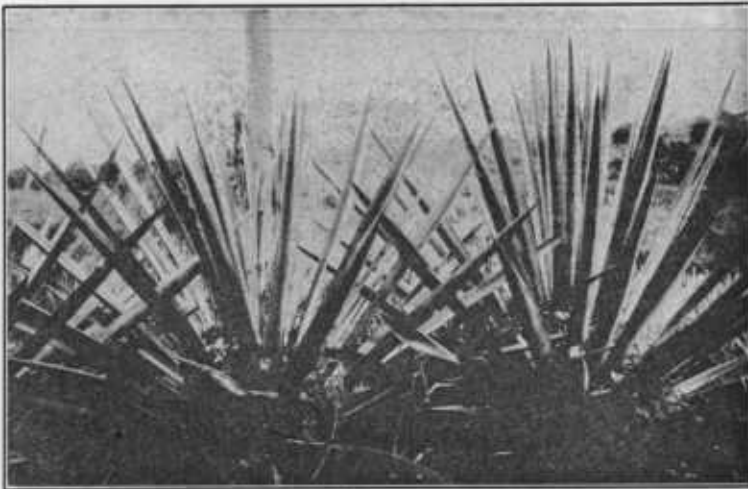


FIG. 2.—SISAL IN PORTO RICO.

Mature plants of the first sisal introduced into Porto Rico from the Bahamas in 1902.

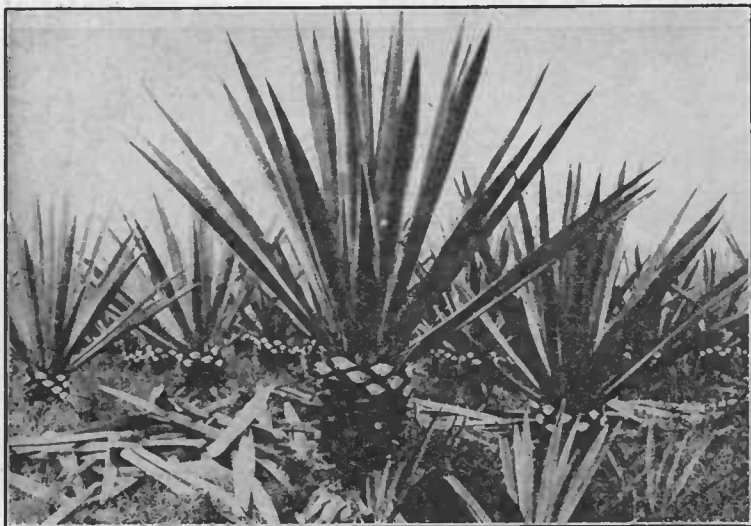


FIG. 1.—HENEQUEN IN YUCATAN.

Well-developed 9-year-old plants from which the sixth semiannual crop has just been cut; total yield to date about 90 leaves per plant.

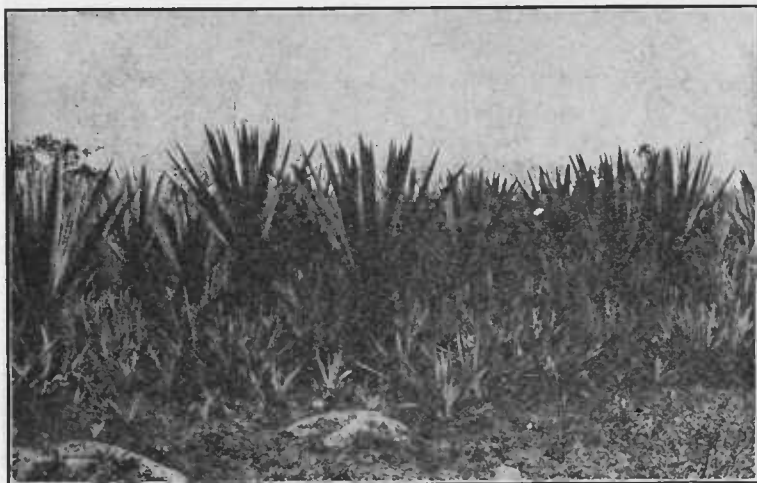


FIG. 2.—HENEQUEN IN CUBA.

Ten-year-old plants which have produced five annual crops, a total of about 150 leaves per plant. Numerous suckers, injurious to mother plants, may be used to stock new plantations.

Plantations have also been established in the States of Chiapas, Sinaloa, and Tamaulipas in Mexico; in Cuba (Pl. XLIX, fig. 2); and, more recently, in Jamaica. Henequen plants have been distributed to some extent in Central America, but, with the exception of limited quantities in Salvador, the fiber is not produced commercially in any of the Central American States. A few henequen plants have been taken to tropical East Africa, the Hawaiian Islands, the Philippine Islands, and India, but the entire production of this fiber outside of Mexico and Cuba is not sufficient materially to affect the total supply.

The true sisal, *Agave sisalana*, is much more widely distributed than henequen. There is scarcely a colony anywhere in the Tropics where sisal plants are not to be found. The principal sisal-producing countries are Java, British East Africa, German East Africa, the Bahamas (Pl. XLVIII, fig. 2), and the Hawaiian Islands, but sisal plantations have also been established in the Philippine Islands, the Caicos Islands, Togoland, Natal, Algeria, Egypt, India, French Indo-China, Taiwan, Australia, New Guinea, Fiji, Jamaica, Curacao, Dutch Guiana, and Demarara.

With this widespread distribution of both henequen and sisal, any attempt to create an artificial monopoly in the production of binder-twine fiber by restricting the exportation of plants from Yucatan is rendered inoperative. An abundant supply of propagating stock is now available in a number of countries other than Yucatan.

#### CLIMATE AND SOIL REQUIREMENTS.

Henequen and sisal can be grown on a commercial scale only in tropical or subtropical countries, and in localities that are free from frost at any season. The lowest temperature recorded in Yucatan is 48° F., and the annual rainfall is about 30 inches. The annual rainfall of northern Cuba, in the districts where the henequen plantations are located, is about 45 inches.

With respect to the soil requirements of these two plants, opinions and practices of experienced planters differ. Because henequen in Yucatan is grown almost exclusively on soils composed largely of porous, partially decomposed coral rock, the opinion prevails very generally that soils of this



character are essential for both henequen and sisal. Results obtained in other countries, especially with sisal, on soils of quite a different character, indicate that this opinion is not based on facts. Even if it is true that rocky limestone soils do furnish the most favorable conditions for henequen and sisal, no difficulty will be experienced in finding large areas of land of this description in countries other than Yucatan.

In the Hawaiian Islands sisal has been grown successfully, both on the rocky limestone soils near the seacoast and on more fertile soils at higher elevations. It is reported that larger yields of fiber have been obtained on the more fertile soils.

In tropical East Africa the soil conditions considered most favorable for sisal are materially different from the conditions on the henequen plantations of Yucatan, as indicated by the following extract from a report of American Consul Henry P. Starrett:

The soil which appears to give the best results is of a red to chocolate color and of a light, friable nature, or a good sandy loam. It should be well limed if that element is lacking, as the plant will not prosper on sour land.

The successful production on a commercial scale of henequen in Cuba and of sisal in Java, the Bahamas, tropical East Africa, the Hawaiian Islands, and elsewhere, clearly establishes the fact that climatic and soil conditions required for the production of henequen and sisal are to be found in many countries.

As henequen and sisal are relatively low-priced crops, yielding a gross return of from \$50 to \$100 annually per acre during their productive life, which is about two-thirds of the time they occupy the land, they can not be expected to yield satisfactory profits on high-priced land.

The production of henequen can not be conducted profitably on a small scale. An area of not less than 300 acres in bearing is required, as a supply of leaves sufficient to keep a fiber-cleaning machine in operation most of the time must be assured.

#### PRODUCTION IN UNITED STATES TERRITORY.

As practically the entire output of Yucatan fiber is exported to the United States, and as by far the greater part of the world's supply of binder twine is manufactured in

this country, the problem of increasing the production of binder-twine fiber in territory under the control of the United States is particularly important.

Henequen has been grown successfully in Porto Rico and in the Philippine Islands. Sisal is now produced on a commercial scale in the Hawaiian Islands and in the Philippine Islands, and in small quantities in Porto Rico and Florida. There is no reason why this industry can not be developed in the Philippine Islands, and there are good prospects for its further development in the Hawaiian Islands, Porto Rico, and Florida.

### THE PHILIPPINE ISLANDS.

The so-called "maguey," *Agave cantala*, is the species of agave most widely cultivated in the Philippine Islands (Pl. L, fig. 1). The maguey plant and the fiber which is obtained from this plant differ somewhat from both the plant and the fiber of henequen and sisal. The maguey leaf has marginal prickles similar to those of the henequen leaf, and the plants of these two species are very similar in appearance. Maguey fiber is finer and softer than that of either henequen or sisal and is not as well suited for binder twine. For this reason and for the further reasons that the yield of maguey is less than that of henequen and sisal and the maguey leaves are more difficult to clean, an attempt is now being made to replace maguey in the Philippines with sisal.

In 1904 the Philippine Bureau of Agriculture investigated the maguey situation in the Philippine Islands, and organized work to encourage the development of this industry. An attempt was made to improve the methods used on the maguey plantations, sisal plants were imported from the Hawaiian Islands, and two small fiber-cleaning machines were purchased by the Philippine Government and operated for demonstration purposes. This work was continued for a period of 12 years, and an industry of some importance was established. During the year ended June 30, 1917, there were exported from the Philippine Islands 14,461 tons of maguey fiber, valued at \$2,348,247.

As the degree of progress was not entirely satisfactory, and as the increased production of binder-twine fiber in the Philippine Islands is of importance to this country, an ar-

rangement was perfected early in 1917 for cooperation between the United States Department of Agriculture and the Philippine Bureau of Agriculture to encourage the production of binder-twine fiber in the Philippine Islands.

In June, 1917, the Department of Agriculture detailed a fiber specialist for work in the Philippines. Subsequently, 250,000 sisal plants and a modern fiber-cleaning machine were purchased and shipped to Manila. The Philippine Bureau of Agriculture detailed several fiber inspectors on extension and demonstration work in the maguey Provinces, collected and distributed sisal and maguey plants, established nurseries, and purchased two fiber-cleaning machines.

The object of this cooperative work has been to stimulate an interest on the part of the Philippine planters in the increased production of binder-twine fiber; to bring about the more general use of improved methods of planting, cultivating, and harvesting; to encourage the substitution of sisal for maguey; and to introduce machine cleaning in place of the "retting" method now in general use (Pl. L, fig. 2).

As a result of this work there has been a marked increase in the planting of maguey and sisal in the Philippines, with some improvement in methods, although progress in this direction is slow. Sisal plants have been widely distributed, and a number of growers who formerly planted maguey are now planting sisal. Fiber-cleaning machines have been installed and successfully operated. Machine-cleaned Philippine sisal that has been submitted to manufacturers is reported to be superior to Yucatan henequen.

With climatic and soil conditions highly favorable; with large areas of cheap, unoccupied land; and with a fairly abundant supply of cheap labor, there are excellent opportunities to increase largely the production of sisal in the Philippine Islands.

#### THE HAWAIIAN ISLANDS.

In 1893 the Commissioner of Agriculture and Forestry of the Hawaiian Islands imported 20,000 sisal plants into that country. The results obtained with these plants were so encouraging that a number of sisal plantations were started in different districts of the islands.



FIG. 1.—MANILA MAGUEY.

Maguey plants at La Carlota Experiment Station of the Philippine Bureau of Agriculture.



FIG. 2.—RETTING MAGUEY.

Fiber-cleaning machines are now being introduced in the Philippine Islands to replace the old method of retting in salt water.



FIG. 1.—SISAL IN PORTO RICO.

Sisal plants in the nursery at the Agricultural Experiment Station, Mayaguez, Porto Rico.

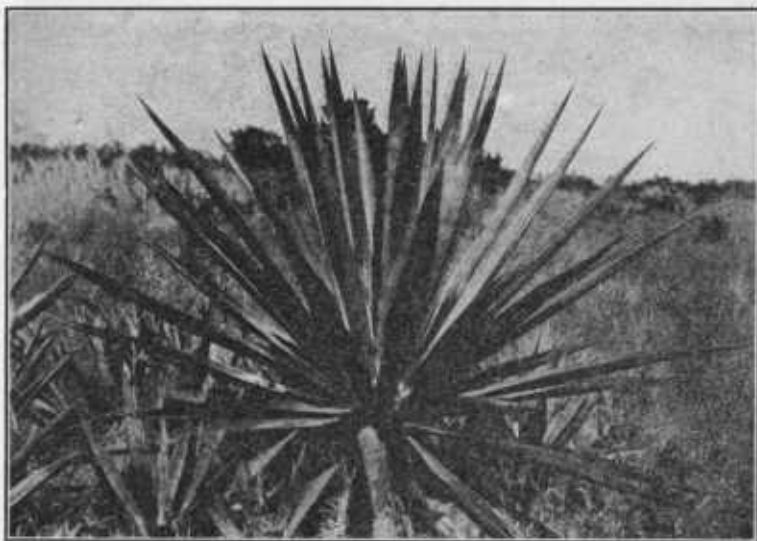


FIG. 2.—SISAL IN FLORIDA.

Sisal plants introduced and naturalized in Florida have furnished propagating stock for almost every tropical colony.

For various reasons the development of the sisal industry in the Hawaiian Islands has not come up to expectations. This has been due, in a large measure, to the fact that the sugar and pineapple industries have absorbed the greater part of the capital and labor available. Two or three sisal plantations are now being operated in the Hawaiian Islands and are producing an exceptionally high grade of fiber. Comparatively large areas of land in the Hawaiian Islands are suitable for sisal, and both climatic and soil conditions are favorable. The labor situation appears to be the most difficult problem in connection with the development of the sisal industry in Hawaii.

#### PORTO RICO.

Sisal planting in Porto Rico has hardly passed the experimental stage, as no commercial plantations have yet been established in this island. Small areas have been planted, and it has been demonstrated that natural conditions are favorable for both henequen and sisal (Pl. LI, fig. 1). A modern fiber-cleaning machine has recently been shipped to Porto Rico by the Department of Agriculture, which will be operated for demonstration purposes. Limited areas of relatively cheap lands not otherwise used, but well adapted to henequen and sisal, are available, and labor at wages comparable with other tropical countries is fairly abundant.

#### FLORIDA.

In southern Florida are large tracts of land where the soil conditions are quite similar to the conditions found in Yucatan and in the henequen-producing districts of northern Cuba. Scattering sisal plants are to be found throughout this part of Florida (Pl. LI, fig. 2). The flourishing condition of these plants indicates that sisal production in southern Florida on a commercial scale is at least a possibility. As sisal is a crop that can be grown profitably only on low-priced land, the establishment of this industry in Florida will depend somewhat on land values. The commercial production of sisal in Florida would make it possible to utilize large areas of land now lying idle, and would also result in a reduction in the imports of sisal from foreign

countries. In Florida, as in the Hawaiian Islands, the most difficult problem in connection with sisal production will be that of labor.

Briefly stated, the results thus far obtained show that it will be entirely practicable to develop a flourishing sisal industry in the Philippine Islands, that natural conditions in the Hawaiian Islands and Porto Rico are favorable for sisal, and that it may be possible to establish this industry in Florida.