HEMP.

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INTRODUCTION.

THE two fiber-producing plants most promising for cultivation in the central United States and most certain to yield satisfactory profits are hemp and flax. The oldest cultivated fiber plant, one for which the conditions in the United States are as favorable as anywhere in the world, one which properly handled improves the land, and which yields one of the strongest and most durable fibers of commerce, is hemp. Hemp fiber, formerly the most important material in homespun fabrics, is now most familiar to the purchasing public in this country in the strong gray tying twines one-sixteenth to one-fourth inch in diameter, known by the trade name "commercial twines."

NAME.

The name "hemp" belongs primarily to the plant *Cannabis sativa*. (Pl. XL, fig. 1.) It has long been used to designate also the long fiber obtained from the hemp plant. (Pl. XL, fig. 4.) Hemp fiber, being one of the earliest and best-known textile fibers and until recent times the most widely used of its class, has been regarded as the typical representative of long fibers. Unfortunately, its name also came to be regarded as a kind of common name for all long fibers, until one now finds in the market quotations "Manila hemp" for abacá, "sisal hemp" for sisal and henequen, "Mauritius hemp" for Furcraea fiber, "New Zealand hemp" for phormium, "Sunn hemp" for Crotalaria fiber, and "India hemp" for jute. All of these fibers in appearance and in economic properties are unlike true hemp, while the name is never applied to flax, which is more nearly like hemp than any other commercial fiber.

The true hemp is known in different languages by the following names: *Cannabis*, Latin; *chanvre*, French; *cañamo*,

Spanish; *canhamo*, Portuguese; *canapa*, Italian; *canep*, Albanian; *konopli*, Russian; *konopj* and *penek*, Polish; *kemp*, Belgian; *hanf*, German; *hennup*, Dutch; *hamp*, Swedish; *hampa*, Danish; *kenevir*, Bulgarian; *ta-ma*, *si-ma*, and *tse-ma*, Chinese; *asa*, Japanese; *nasha*, Turkish; *kanabira*, Syrian; *kannab*, Arabic.

IMPORTANCE OF HEMP.

Hemp was formerly the most important long fiber, and it is now used more extensively than any other soft fiber except jute. From 10,000 to 15,000 tons are used in the United States every year. The approximate amount consumed in American spinning mills is indicated by the following table, showing the average annual importations [1] and estimates of average domestic production of hemp fiber for 35 years:

Average annual imports and estimates of average annual production of hemp fiber in 5-year periods from 1876 to 1910, inclusive, and from 1911 to 1913, inclusive.

Years.	Imports.	Production in United States.	Total.
	Tons.	*Tons.*	*Tons.*
1876 to 1880.....	459	7,396	7,855
1881 to 1885.....	5,393	5,421	10,814
1886 to 1890.....	10,427	8,270	18,697
1891 to 1895.....	4,962	5,631	10,593
1896 to 1900.....	4,985	5,177	10,162
1901 to 1905.....	4,577	6,175	10,752
1906 to 1910.....	6,375	5,150	11,525
1911 to 1913.....	5,982	5,100	11,082

There are no statistics available, such as may be found for wheat, corn, or cotton, showing with certainty the acreage and production of hemp in this country. The estimates of production in the foregoing table are based on the returns of the Commissioner of Agriculture of Kentucky for earlier years with amounts added to cover the production in other States, and on estimates of hemp dealers for more recent years. While these figures can not be regarded as accurate statistics, and they are probably below rather than above the actual production, especially in the earlier years,

[1] Computed from reports of the Bureau of Navigation and Commerce, U. S. Treasury Department, and Bureau of Statistics, Department of Commerce.

they indicate a condition well recognized by all connected with the industry. The consumption of hemp fiber has a slight tendency to increase, but the increase is made up through increased importations, while the domestic production shows a tendency toward reduction.

PRODUCTION IN UNITED STATES DECLINING.

This falling off in domestic production has been due primarily to the increasing difficulty in securing sufficient labor to take care of the crop; secondarily, to the lack of development of labor-saving machinery as compared with the machinery for handling other crops and to the increasing profits in raising stock, tobacco, and corn, which have largely taken the attention of farmers in hemp-growing regions.

The work of retting, breaking, and preparing the fiber for market requires a special knowledge, different from that for handling grain crops, and a skill best acquired by experience. These factors have been more important than all others in restricting the industry to the bluegrass region of Kentucky, where the plantation owners as well as the farm laborers are familiar with every step in handling the crop and producing the fiber.

An important factor, tending to restrict the use of hemp, has been the rapidly increasing use of other fibers, especially jute, in the manufacture of materials formerly made of hemp. Factory-made woven goods of cotton or wool, more easily spun by machinery, have replaced the hempen "homespun" for clothing; wire ropes, stronger, lighter, and more rigid, have taken its place in standing rigging for ships; abacá (Manila hemp), lighter and more durable in salt water, has superseded it for towing hawsers and hoisting ropes; while jute, inferior in strength and durability, and with only the element of cheapness in its favor, is usurping the legitimate place of hemp in carpet warps, so-called "hemp carpets," twines, and for many purposes where the strength and durability of hemp are desired.

The introduction of machinery for harvesting hemp and also for preparing the fiber, together with the higher prices paid for hemp during the past three years, has aroused an interest in the industry, and many experiments are being tried with a view to the cultivation of the crop in new areas.

BOTANICAL STUDY OF HEMP

THE PLANT.

The hemp plant, *Cannabis sativa* L.,[1] is an annual, growing each year from the seed. It has a rigid, herbaceous stalk, attaining a height of 1 to 5 meters (3 to 16 feet), obtusely 4-cornered, more or less fluted or channeled, and with well-marked nodes at intervals of 10 to 50 centimeters (4 to 20 inches). When not crowded it has numerous spreading branches, and the central stalk attains a thickness of 3 to 6 centimeters (1 to 2 inches), with a rough bark near the base. If crowded, as when sown broadcast for fiber, the stalks are without branches or foliage except at the top, and the smooth fluted stems are 6 to 20 millimeters ($\frac{1}{4}$ to $\frac{3}{4}$ inch) in diameter. The leaves, opposite, except near the top or on the shortened branches, appearing fascicled, are palmately compound and composed of 5 to 11—usually 7—leaflets. (Pl. XLI, fig. 1.) The leaflets are dark green, lighter below, lanceolate, pointed at both ends, serrate, 5 to 15 centimeters (2 to 6 inches) long, and 1 to 2 centimeters ($\frac{3}{8}$ to $\frac{3}{4}$ inch) wide. Hemp is dicœcious, the staminate or pollen-bearing flowers and the pistillate or seed-producing flowers being borne on separate plants. The staminate flowers (Pl. XL, fig. 2) are borne in small axillary panicles, and consist of five greenish yellow or purplish sepals opening wide at maturity and disclosing five stamens which discharge abundant yellow pollen. The pistillate flowers (Pl. XL, fig. 3) are stemless and solitary in the axils of the small leaves near the ends of the branches, often crowded so as to appear like a thick spike. The pistillate flower is inconspicuous, consisting of a thin, entire, green calyx, pointed, with a slit at one side, but remaining nearly closed over the ovary and merely permitting the two small stigmas to protrude at the apex. The ovary is one seeded, developing into a smooth, compressed or nearly spherical achene (the "seed"), 2.5 to 4 millimeters ($\frac{1}{10}$ to $\frac{5}{16}$ inch) thick and 3 to 6 millimeters ($\frac{1}{8}$ to $\frac{1}{4}$ inch) long, from dark gray to light brown in color and mottled (Pl. XLI, fig. 2). The seeds cleaned for market nearly always include some still covered with the green, gummy calyx. The seeds vary in weight from 0.008 to 0.027 gram, the dark-colored seeds being generally much heavier than the light-colored seeds of the same sample. The light-colored seeds are often imperfectly developed. Dark-colored and distinctly mottled seeds are generally preferred.

The staminate plants are often called the flowering hemp, since the pistillate flowers are rarely observed. The staminate plants die after the pollen is shed, but the pistillate plants remain alive and green two months later, or until the seeds are fully developed.

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[1] Linnæus. Species Plantarum, ed. 1, 1027, 1753.
Dioscorides. Medica Materia, libri sex, p. 147, 1537.
Synonyms: *Cannabis erratica paludosa* Anders. Lobel. Stirpium Historia, 284, 1576.
Cannabis indica Lamarck. Encyclopaedia, 1: 695, 1738.
Cannabis macrosperma Stokes. Bot. Mat. Med., IV, 539, 1812.
Cannabis chinensis Delile. Ind. Sem. Hort. Monst. in Ann. Sci. Nat. Bot., 12: 365, 1849.
Cannabis gigantea Delile. L. Vilmorin. Rev. Hort., 5: s. 3, 109, 1851.

THE STALK.

The hemp stalk is hollow, and in the best fiber-producing types the hollow space occupies at least one-half the diameter. The hollow space is widest, or the surrounding shell thinnest, about midway between the base and the top of the plant. The woody shell is thickened at each node, dividing the hollow space into a series of partly separated compartments. (Pl. XLI, fig. 4.) If the stalk is cut crosswise a layer of pith, or thin-walled tissue, is found next to the hollow center, and outside of this a layer of wood composed of hard, thick-walled cells. This layer, which forms the "hurds," is a very thin shell in the best fiber-producing varieties. It extends clear across the stem below the lowest node, and in large, coarse stalks grown in the open it is much thicker and the central hollow relatively smaller. Outside of the hard woody portion is the soft cambium, or growing tissue, the cells of which develop into the wood on the inside, or into the bast and bark on the outside. It is chiefly through this cambium layer that the fiber-bearing bast splits away from the wood in the processes of retting and breaking. Outside of the cambium is the inner bark, or bast, comprising short, thin-walled cells filled with chlorophyll, giving it a green color, and long thick-walled cells, making the bast fibers. These bast fibers are of two kinds, the smaller ones (secondary bast fibers) toward the inner portion making up rather short, fine fibers, many of which adhere to the wood or hurds when the hemp is broken, and the coarser ones (primary bast fibers) toward the outer part, extending nearly throughout the length of the stalk. Outside of the primary bast fiber is a continuation of the thin-walled chlorophyll-bearing cells free from fiber, and surrounding all is the thin epidermis.

THE FIBER.

The hemp fiber of commerce is composed of the primary bast fibers, with some adherent bark and also some secondary bast fiber. The bast fibers consist of numerous long, overlapping, thick-walled cells with long, tapering ends. The individual cells, almost too small to be seen by the unaided eye, are 0.015 to 0.05 millimeter ($\frac{3}{1000}$ to $\frac{12}{1000}$ inch) in diameter, and 5 to 55 millimeters ($\frac{3}{16}$ to $2\frac{1}{8}$ inches) long. Some of the bast fibers extend through the length of the stalk, but some are branched, and some terminate at each node. They are weakest at the nodes.

RELATIONSHIPS.

The hemp plant belongs to the mulberry family, Moraceæ, which includes the mulberry, the Osage orange, the paper mulberry, from the bast of which the tapa of the South Sea Islands is made, and the hop, which contains a strong bast fiber. Hemp is closely related to the nettle family, which includes ramie, an important fiber-producing plant of Asia, and several species of nettles having strong bast fibers.

The genus Cannabis is generally regarded by botanists as monotypic, and the one species *Cannabis sativa* is now held to include the half dozen forms which have been described under different names (see footnote, p. 286) and which are cultivated for different purposes. The foregoing description refers especially to the forms cultivated for the production of fiber.

HISTORY.

EARLY CULTIVATION IN CHINA.

Hemp was probably the earliest plant cultivated for the production of a textile fiber. The "Lu Shi," a Chinese work of the Sung dynasty, about 500 A. D., contains a statement that the Emperor Shen Nung, in the twenty-eighth century B. C., first taught the people of China to cultivate "ma" (hemp) for making hempen cloth. The name *ma* (fig. 17) occurring in the earliest Chinese writings designated a plant of two forms, male and female, used primarily for fiber. Later the seeds of this plant were used for food.[1] The definite statement regarding the staminate and pistillate forms eliminates other fiber plants included in later times under the Chinese name *ma*. The Chinese have cultivated the plant for the production of fiber and for the seeds, which were used for food and later for oil, while in some places the stalks are used for fuel, but there seems to be no record that they have used the plant for the production of the narcotic drugs bhang, charas, and ganga. The production and use of these drugs were developed farther west.

FIG. 17.—Chinese character *ma*, the earliest name for hemp.

CULTIVATION FOR NARCOTIC DRUGS.

The use of hemp in medicine and for the production of the narcotic drug Indian hemp, or cannabis, is of interest in this paper only because of its bearing on the origin and development of different forms of the plant. The origin of this use is not definitely known, but the weight of evidence

[1] Bretschneider, E. Botanicum Sinicum, in Journal of the North China Branch of the Royal Asiatic Society, n. s., v. 25, p. 203, 1893, Shanghai.

seems to indicate central Asia or Persia and a date many centuries later than its first cultivation for fiber. The name *bhanga* occurs in the Sanskrit "Atharvavéda" (about 1400 B. C.), but the first mention of it as a medicine seems to be in the work of Susruta (before the eighth century A. D.), while in the tenth century A. D. its intoxicating nature seems to have been known, and the name "indraçana" (Indra's food) first appears in literature.[1] A further evidence that hemp, for the production of fiber as well as the drug, has been distributed from central Asia or Persia is found in the common origin of the names used. The Sanskrit names "bhanga" and "gangika," slightly modified to "bhang" and "ganja," are still applied to the drugs, and the roots of these words, "ang" and "an," recur in the names of hemp in all of the Indo-European and modern Semitic languages, as bhang, ganja, hanf, hamp, hemp, chanvre, cañamo, kannab, cannabis.[2]

HEMP IN INDIA.

Northern India has been regarded by some writers as the home of the hemp plant, but it seems to have been unknown in any form in India before the eighth century, and it is now thought to have been introduced there first as a fiber plant. It is still cultivated to a limited extent for fiber in Kashmir and in the cool, moist valleys of the Himalayas, but in the warmer plains regions it is grown almost exclusively for the production of the drugs.[3]

Hemp was not known to the Hebrews nor to the ancient Egyptians, but in medieval times it was introduced into North Africa, where it has been cultivated only for the drug. It is known in Morocco as "kif," and a small form, 1 to 3 feet high, cultivated there has been described as a distinct variety, *Cannabis sativa kif*.[4]

INTRODUCTION INTO EUROPE.

According to Herodotus (about 450 B. C.), the Thracians and Scythians, beyond the Caspian Sea, used hemp, and it is probable that the Scythians introduced the plant into Europe in their westward migration, about 1500 B. C.,

[1] Watt, Sir George. Commercial Products of India, p. 251, 1908.
[2] De Candolle, Alphonse. Origin of Cultivated Plants, p. 148, 1886.
[3] Watt, Sir George. Commercial Products of India, p. 253, 1908.
[4] De Candolle, Alphonse. Prodromus, v. 16, pt. 1, p. 31, 1869.

though it seems to have remained almost unknown to the Greeks and Romans until the beginning of the Christian era. The earliest definite record of hemp in Europe is the statement that "Hiero II, King of Syracuse (270 B. C.), bought hemp in Gaul for the cordage of his vessels."[1] From the records of Tragus (1539 A. D.), hemp in the sixteenth century had become widely distributed in Europe. It was cultivated for fiber, and its seeds were cooked with barley and other grains and eaten, though it was found dangerous to eat too much or too frequently. Dioscorides called the plant *Cannabis sativa*, a name it has continued to bear to the present time, and he wrote of its use in "making the stoutest cords" and also of its medicinal properties.[2] Nearly all of the early herbalists and botanical writers of Europe mention hemp, but there is no record of any further introduction of importance in the fiber industry until the last century.

INTRODUCTION OF CHINESE HEMP INTO EUROPE.

In 1846 M. Hébert sent from China to the Museum at Paris some seeds of the "tsing-ma," great hemp, of China. Plants from this seed, grown at Paris by M. L. Vilmorin, attained a height of more than 15 feet, but did not produce seeds. In the same year M. Itier sent from China to M. Delile, of the Garden at Montpellier, France, seeds of a similar kind of hemp. These seeds were distributed in the southern part of France, where the plants not only grew tall, some of them measuring 21 feet, but they also produced mature seeds. M. Delile called this variety *Cannabis chinensis*[3] and the one from the seeds sent by M. Hébert he called *C. gigantea*.[4] These two forms of hemp were regarded as the same by M. L. Vilmorin, who states that they differ very much in habit from the common hemp of Europe, which was shorter and less valuable for fiber production. We are also told that this chanvre de Chine did not appear to be the same as the chanvre de Piedmont,[5] the tall hemp of eastern France and northern Italy, the origin of which has sometimes been referred to this introduction, but this

[1] De Candolle, Alphonse. Origin of Cultivated Plants, p. 148, 1886.
[2] Dioscorides. Medica Materia, li bri sex, p. 147, 1537.
[3] Delile, Raffenau. Index seminum horti botanici Monspeliensis. Ann. Sci. Nat. Bot., v. 12, p. 365, 1849.
[4] Vilmorin, L. Chanvre de Chine. Rev. Hort. 5: s. 3, p. 109, 1851.
[5] Pépin. Sur le chanvre de Chine. Rev. Hort. 1: s. 3, p. 199, 1847.

may have originated in a previous introduction, since *Cannabis chinensis* is mentioned as having been in the Botanical Garden at Vienna in 1827. In the same statement, however, *C. sativa pedemontana* is described as a distinct variety.[1] Particular attention is called to the introduction of this large Chinese hemp into Europe, since it was doubtless from the same source as the best hemp seed now brought from China to the United States.

INTRODUCTION INTO SOUTH AMERICA.

Hemp from Spain was introduced into Chile about 1545.[2] It has been largely grown in that country, but at present its cultivation is confined chiefly to the fertile lands in the valley of the Rio Aconcagua, between Valparaiso and Los Andes, where there are large cordage and twine mills. The fiber is all consumed in these mills.

INTRODUCTION INTO NORTH AMERICA.

Hemp was introduced into New England soon after the Puritan settlements were established, and the fact that it grew "twice so high" as it did in old England was cited as evidence of the superior fertility of the soil of New England.[3] A few years later a writer in Virginia records the statement that "They begin to plant much Hempe and Flax which they find growes well and good."[4] The cultivation of hemp in the New England colonies, while continued for some time in Massachusetts and Connecticut, did not attain as much importance as the cultivation of flax for supplying fiber for household industry. In the South hemp received more attention, especially from the Virginia Legislature, which passed many acts designed to promote the industry, but all in vain.[5]

The cultivation of hemp seems to have been a flourishing industry in Lancaster County, Pa., before the Revolution. An elaborate account of the methods then employed in

[1] De Candolle, Alphonse. Prodromus, v. 16, pt. 1, p. 31, 1869.

[2] Husbands, José D. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 153, p. 42, 1909.

[3] Morton, Thomas. New English Canaan, p. 64, 1632. *In* Force, Peter, Tracts and Other Papers, v. 2, 1838.

[4] Virginia, printed for Richard Wodenoth, 1649. *In* Force, Peter, Tracts and Other Papers, v. 2, 1838.

[5] Moore, Brent. A Study of the Past, the Present, and the Possibilities of the Hemp Industry in Kentucky, p. 14, 1905.

growing hemp, written about 1775 by James Wright, of Columbia, Pa.,[1] was recently published as an historical document. The methods described for preparing the land were equal to the best modern practice, but the hemp was pulled by hand instead of cut. Various kinds of machine brakes had been tried, but they had all "given Way to one simple Break of a particular Construction, which was first invented & made Use of in this country." The brief description indicates the common hand brake still in use in Kentucky.

EARLY CULTIVATION IN KENTUCKY.

The first crop of hemp in Kentucky was raised by Mr. Archibald McNeil, near Danville, in 1775.[2] It was found that hemp grew well in the fertile soils of the bluegrass country, and the industry was developed there to a greater extent than it had been in the eastern colonies. While it was discontinued in Massachusetts, Virginia, and Pennsylvania, it has continued in Kentucky to the present time. In the early days of this industry in Kentucky, fiber was produced for the homespun cloth woven by the wives and daughters of the pioneer settlers, and an export trade by way of New Orleans was developed. In 1802 there were two extensive ropewalks in Lexington, Ky., and there was announced "a machine, moved by a horse or a current of water, capable, according to what the inventor said, to break and clean eight thousand weight of hemp per day."[3] Hemp was later extensively used for making cotton-bale covering. Cotton bales were also bound with hemp rope until iron ties were introduced, about 1865. There was a demand for the better grades of hemp for sailcloth and for cordage for the Navy, and the industry was carried on more extensively from 1840 to 1860 than it has been since.

EXTENSION OF THE INDUSTRY TO OTHER STATES.

Hemp was first grown in Missouri about 1835, and in 1840 1,600 tons were produced in that State. Four years later the output had increased to 12,500 tons, and it was thought that Missouri would excel Kentucky in the production of

[1] New Era, Lancaster, Pa., June 24, 1905.

[2] Moore, Brent. A Study of the Past, the Present, and the Possibilities of the Hemp Industry in Kentucky, p. 16, 1905.

[3] Michaux, F. Andre. Travels to the west of the Alleghanies, p. 152, 1805. *In* Thwaites, Early Western Travels, v. 3, p. 200, 1904.

this fiber. With the unsatisfactory methods of cleaning the fiber on hand brakes and the difficulties of transporting the fiber to the eastern markets, hemp proved less profitable than other crops, and the industry was finally abandoned about 1890.

Hemp was first grown at Champaign, Ill., about 1875. A cordage mill was established there for making twines from the fiber, which was prepared in the form of long tow by a large machine brake. The cordage mill burned and the industry was discontinued in 1902 because there was no satisfactory market for the kind of tow produced.

In Nebraska, hemp was first grown at Fremont in 1887 by men from Champaign, Ill. A binder-twine plant was built, but owing to the low price of sisal, more suitable for binder twine, most of the hemp was sold to eastern mills to be used in commercial twines. After experimenting with machine brakes the company brought hand brakes from Kentucky and colored laborers to operate them. The laborers did not stay, and the work was discontinued in 1900. Some of the men who had been connected with the company at Fremont began growing hemp at Havelock, near Lincoln, in 1895. A machine for making long tow, improved somewhat from the one at Champaign, was built. Further improvements were made in the machine and also in the methods of handling the crop, but the industry was discontinued in 1910, owing to the lack of a satisfactory market for the kind of tow produced.

Hemp was first grown on a commercial scale in California at Gridley, in Butte County, by Mr. John Heaney, who had grown it at Champaign and who devised the machine used there for making long tow. Mr. Heaney built a machine with some improvements at Gridley, and after three disastrous inundations from the Feather River moved to Courtland, in the lower Sacramento Valley, where the reclaimed lands are protected by dikes. The work is now being continued at Rio Vista, in Solano County, under more favorable conditions and with a machine still further improved. The hemp fiber produced in California is very strong and is generally lighter in color than that produced in Kentucky.

In 1912 hemp was first cultivated on a commercial scale under irrigation at Lerdo, near Bakersfield, Cal., and a larger acreage was grown there in 1913. The seed for both crops was obtained in Kentucky.

INTRODUCTION OF CHINESE HEMP INTO AMERICA.

In 1857 the first Chinese hemp seed was imported. It met with such favor that some of this seed is said to have brought $10 per quart.[1] Since that time the common hemp of European origin has given place in this country to the larger and better types from China.

GEOGRAPHICAL DISTRIBUTION.

The original home of the hemp plant was in Asia, and the evidence points to central Asia, or the region between the Himalayas and Siberia. Historical evidence must be accepted rather than the collection of wild specimens, for hemp readily becomes naturalized, and it is now found growing without cultivation in all parts of the world where it has been introduced. Hemp is abundant as a wild plant in many localities in western Missouri, Iowa, and in southern Minnesota, and it is often found as a roadside weed throughout the Middle West. De Candolle[2] writes of its origin as follows:

> The species has been found wild, beyond a doubt, south of the Caspian Sea (De Bunge); in Siberia, near the Irtysch; and in the Desert of Kirghiz, beyond Lake Baikal, in Dahuria (Government of Irkutsh). It is found throughout central and southern Russia and south of the Caucasus, but its wild nature here is less certain. I doubt whether it is indigenous in Persia, for the Greeks and Hebrews would have known of it earlier.

Hemp is now cultivated for the production of fiber in China, Manchuria, Japan, northern India, Turkey, Russia, Austria-Hungary, Italy, France, Belgium, Germany, Sweden, Chile, and in the United States. It is grown for the production of the drugs bhang, ganja, kif, marihuana, hasheesh, etc., in the warm, arid, or semiarid climates of India, Persia, Turkey, Algeria, central and southern Africa, and in Mexico, and for the production of seed for oil in China and Manchuria.

In the United States hemp is now cultivated in the bluegrass region of Kentucky within a radius of 50 miles of Lexington; in the region of Waupun, Wis.; in northern Indiana; near Lima, Ohio; and at Lerdo and Rio Vista, Cal. There are numerous small experimental plats in other places.

The principal countries producing hemp fiber for export are Russia, Italy, Hungary, and Roumania. China and

[1] Moore, Brent. The Hemp Industry in Kentucky, pp. 60-61, 1905.
[2] De Candolle, Alphonse. Origin of Cultivated Plants, p. 148, 1886.

Japan produce hemp fiber of excellent quality, but it is nearly all used for home consumption. Hemp is not cultivated for fiber in the Tropics or in any of the warm countries.

The historical distribution of hemp, as nearly as may be traced from the records, and the areas where hemp is now cultivated are indicated in the accompanying map, figure 6.

VARIETIES.

Hemp, cultivated for three different products—fiber from the bast, oil from the seeds, and resinous drugs from the flowers and leaves—has developed into three rather distinct types or groups of forms. The extreme, or more typical, forms of each group have been described as different species, but the presence of intergrading forms and the fact that the types do not remain distinct when cultivated under new conditions make it impossible to regard them as valid species.

There are few recognized varieties in either group. Less than 20 varieties of fiber-producing hemp are known, although hemp has been cultivated for more than 40 centuries, or much longer than either cotton or corn, both of which now have hundreds of named varieties.

CHINA.

The original home of the hemp plant was in China, and more varieties are found there than elsewhere. It is cultivated for fiber in nearly all parts of the Chinese Republic, except in the extreme south, and over a wide range of differences in soil and climate with little interchange of seed, thus favoring the development and perpetuation of varietal differences.

The variety called "ta-ma" (great hemp) is cultivated chiefly in the provinces of Chekiang, Kiangsu, and Fukien, south of the Yangtze. In the rich lowland soils, often in rotation with rice, but not irrigated, and with a warmer and longer growing season than in Kentucky, this hemp attains a height of 10 to 15 feet. The seed is dark colored, usually well mottled, small, weighing about 1.2 grams per hundred. The internodes of the main stem are 6 to 10 inches long; the branches long and slender, usually drooping at the ends; the leaves large; and the pistillate flowers in small clusters.

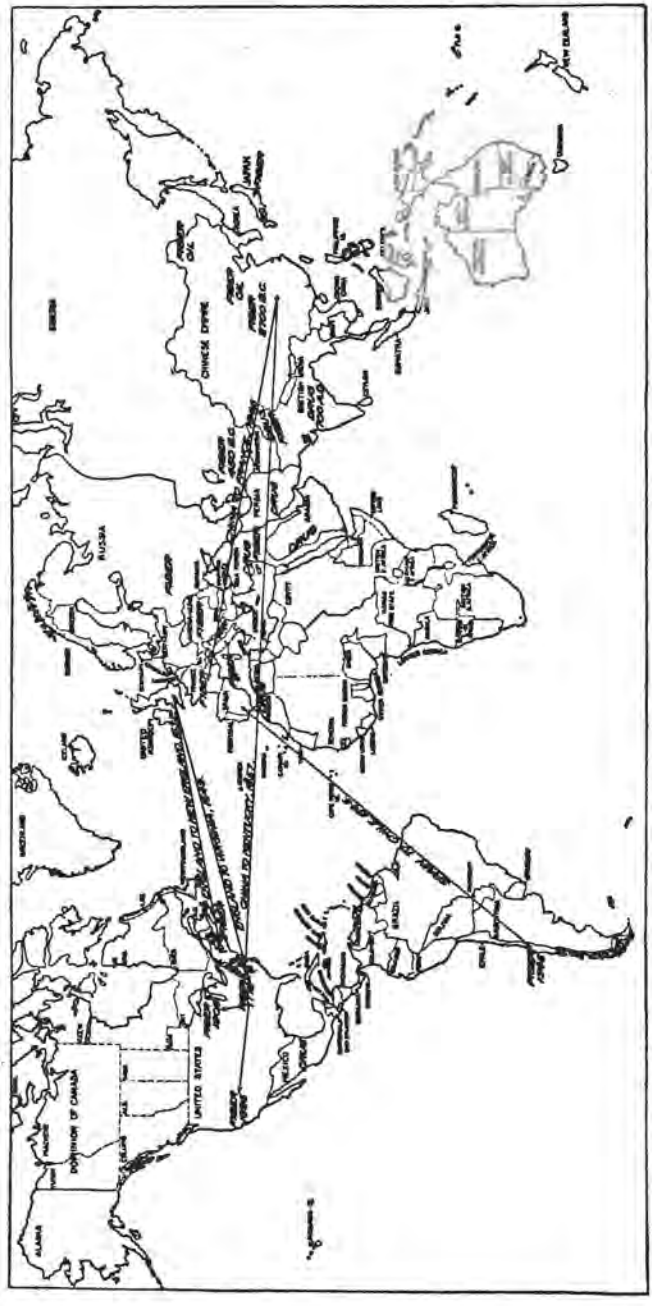


FIG. 18.—Map of the world, showing the location of hemp cultivation for fiber, oil, and drug, with the sources and dates of introduction.

Seed brought from China to Kentucky in recent years is mostly of this variety. When first introduced it is too long in maturing to permit all of the seeds to ripen.

The most important fiber plant of western China is the variety of hemp called "hoa-ma." It is grown in the province of Szechwan and as a winter crop on the plains of Chengtu in that province. It is shorter and more compact in its habit of growth and earlier in maturing than the ta-ma of the lowlands.

A variety called "shan-ma-tse" is cultivated in the mountain valleys in the provinces of Shansi and Chihli, in northern China. Its fiber is regarded as the best in North China, and in some respects as superior to that of ta-ma, though the yield is usually smaller. The plants attain a height of 6 to 9 feet, with a very thin woody shell, short ascending branches, rather small leaves, and larger seeds in larger clusters than those of ta-ma. Imported seed of this variety, grown in a trial plat in Kentucky, produced plants smaller in size and maturing earlier than Kentucky hemp.

In the mountains both north and south of Ichang in central China a variety called "t'ang-ma" (cold hemp) is cultivated primarily for the production of seeds, from which oil is expressed. It is a very robust form, with stalks 6 to 12 feet high and 2 to 4 inches in diameter. These stalks are used for fuel, and occasionally a little fiber is stripped off for domestic use.

In Manchuria two distinct kinds of hemp are cultivated. One, called "hsien-ma," very similar to the shan-ma-tse of northern China, is grown for fiber. It attains a height of 8 to 9 feet, and requires nearly 150 days from seeding to full maturity. The other, called "shem-ma," is grown for oil-seed production. It attains a height of 3 to 5 feet and is ripe with fully matured seeds in less than 100 days. The branches usually remain undeveloped, so that the clusters of seeds are borne in compact heads at the tops of the simple stalks. (Pl. XLII, fig. 1.) It is said that in Manchuria these two forms remain distinct without crossing or producing any intergrading forms.

The Chinese name "ma" (fig. 17), originally applied only to the true hemp (*Cannabis sativa*), is now used as a

general term to designate nearly all textile plants in China.[1] This general use leads to nearly as much confusion among English-speaking people in China as does the unfortunate use of the name hemp as a synonym for fiber in this country. The staminate hemp plant is called "si-ma," and the pistillate plant "tsu-ma." Flax, cultivated to a limited extent in northern China, is called "siao-ma" (small hemp), but this name is also applied to small plants of true hemp. Ramie, cultivated in central and southern China, is "ch'u-ma" or "tsu-ma." China jute, cultivated in central and northern China and in Manchuria and Chosen (Korea), is called "tsing-ma," or "ching-ma," and its fiber, exported from Tientsin, is called "pei-ma." India jute, cultivated in southern China and Taiwan, is called "oi-ma." The name "chih-ma" is also applied in China to sesame, which is not a fiber plant.

JAPAN.

Hemp, called "asa" in the Japanese language, is cultivated chiefly in the provinces or districts of Hiroshima, Tochigi, Shimane, Iwate, and Aidzu, and to a less extent in Hokushu (Hokkaido) in the north and Kiushu in the south. It is cultivated chiefly in the mountain valleys, or in the north on the interior plains, where it is too cool for cotton and rice and where it is drier than on the coastal plain. That grown in Hiroshima, in the south, is tall, with a rather coarse fiber; that in Tochigi, the principal hemp-producing province, is shorter, 5 to 7 feet high, with the best and finest fiber, and in Hokushu it is still shorter.

Seeds from Hiroshima, Shimane, Aidzu, Tochigi, and Iwate were tried by the United States Department of Agriculture in 1901 and 1902. The plants showed no marked varietal differences. They were all smaller than the best Kentucky hemp. The seeds varied from light grayish brown, 5 millimeters ($\frac{1}{5}$ inch) long, to dark gray, 4 millimeters ($\frac{1}{6}$ inch) long. The largest plants in every trial plat were from Hiroshima seeds, and these seeds were larger and lighter colored than those of any other variety except Shimane, the seeds of which were slightly larger and the plants slightly smaller.

[1] Bretschneider, E. Botanicum Sinicum, p. 203, 1893.

RUSSIA.

Hemp is cultivated throughout the greater part of Russia, and it is one of the principal crops in the provinces of Orel, Kursk, Samara, Smolensk, Tula, Voronezh, and Poland. Two distinct types, similar to the tall fiber hemp and the short oil-seed hemp of Manchuria, are cultivated, and there are doubtless many local varieties in isolated districts where there is little interchange of seed. The crop is rather crudely cultivated, with no attempt at seed selection or improvement, and the plants are generally shorter and coarser than the hemp grown in Kentucky. The short oil-seed hemp with slender stems, about 30 inches high, bearing compact clusters of seeds and maturing in 60 to 90 days, is of little value for fiber production, but the experimental plats, grown from seed imported from Russia, indicate that it may be valuable as an oil-seed crop to be harvested and thrashed in the same manner as oil-seed flax.

HUNGARY.

The hemp in Hungary has received more attention in recent years than that in Russia, and this has resulted in a better type of plants. An experimental plat grown at Washington from Hungarian seed attained a height of 6 to 10 feet in the seed row. The internodes were rather short, the branches numerous, curved upward, and bearing crowded seed clusters and small leaves. About one-third of the plants had dark-purple or copper-colored foliage and were more compact in habit than those with normal green foliage.

ITALY.

The highest-priced hemp fiber in the markets of either America or Europe is produced in Italy,[1] but it is obtained from plants similar to those in Kentucky. The higher price of the fiber is due not to superior plants, but to water retting and to increased care and labor in the preparation of the fiber.

Four varieties are cultivated in Italy:

(1) "Bologna," or great hemp, called in France "chanvre de Piedmont," is grown in northern Italy in the provinces of Bologna, Ferrara, Roviga,

[1] Bruck, Werner F. Studien über den Hanfbau in Italien, p. 7, 1911.

and Modena. In the rich alluvial soils and under the intensive cultivation there practiced this variety averages nearly 12 feet in height, but it is said to deteriorate rapidly when cultivated elsewhere.

(2) "Cannapa picola," small hemp, attaining a height of 4 to 7 feet, with a rather slender reddish stalk, is cultivated in the valley of the Arno in the department of Tuscany.[1]

(3) "Neapolitan," large seeded.

(4) "Neapolitan," small seeded.

The two varieties of Neapolitan hemp are cultivated in the vicinity of Naples, and even so far up on the sides of Vesuvius that fields of hemp are occasionally destroyed by the eruptions of that volcano.

Seed of each of these Italian varieties has been grown in trial plats at Washington, D. C., and Lexington, Ky. The Bologna, or Piedmont, hemp in seed rows attained a height of 8 to 11 feet, nearly as tall as Kentucky seed hemp grown for comparison, but with thicker stalks, shorter and more rigid branches, and smaller and more densely clustered leaves. The small hemp, cannapa picola, was only 4 to 6 feet high. The large-seeded Neapolitan was 7 to 10 feet high, smaller than the Bologna, but otherwise more like Kentucky hemp, with more slender stalks and more open foliage. The small-seeded Neapolitan, with seeds weighing less than 1 gram per 100, rarely exceeded 4 feet in height in the series of plats where all were tried.

FRANCE.

Hemp is cultivated in France chiefly in the departments of Sarthe and Ille-et-Vilaine, in the valley of the Loire River. Two varieties are grown, the Piedmont, from Italian seed, and the common hemp of Europe. The former grows large and coarse, though not as tall as in the Bologna region, and it produces a rather coarse fiber suitable for coarse twines. The latter, seed of which is sown at the rate of 1½ to 2 bushels per acre, has a very slender stalk, rarely more than 4 or 5 feet high, producing a fine flaxlike fiber that is largely used in woven hemp linens.

The common hemp of Europe, which includes the short hemp of France, is also cultivated to a limited extent in Spain, Belgium, and Germany. It grows taller and coarser when sown less thickly on rich land, but it never attains the size of the Bologna type.

[1] Dodge, Charles Richards. Culture of hemp in Europe. U. S. Department of Agriculture, Fiber Investigations, Report No. 11, p. 6, 1898.

CHILE.

Chilean hemp, originally from seed of the common hemp of Europe, has developed in three and a half centuries into coarser plants with larger seeds. When sown broadcast for fiber in Chile the plants attain a height of 6 to 8 feet, and when in checks or drills for seed they reach 10 to 12 feet.

Hemp from Chilean seed (S. P. I. No. 24307), grown at the experiment stations at Lexington, Ky., and St. Paul, Minn., in 1909, was 4 to 9 feet high in the broadcast plats and about the same height in the seed drills. It matured earlier than hemp of Chinese origin. Its leaves were small and crowded, with the seed clusters near the ends of slender, spreading branches. The fiber was coarse and harsh. The seeds were very large, 5 to 6 millimeters long, and weighed about 2 grams per 100.

TURKEY.

A variety of hemp, intermediate between the fiber-producing and the typical drug-producing types, is cultivated in Asiatic Turkey, especially in the region of Damascus, and to a limited extent in European Turkey. This variety, called Smyrna, is about the poorest variety from which fiber is obtained. It is cultivated chiefly for the narcotic drug, but fiber is also obtained from the stalks. It grows 3 to 6 feet high, with short internodes, numerous ascending branches, densely crowded foliage of small leaves, and abundant seeds maturing early. It seems well suited for the production of birdseed, but its poor type, combined with prolific seed production, makes it a dangerous plant to grow in connection with fiber crops.

INDIA.

Hemp is cultivated in India over an area of 2,000 to 5,000 acres annually for the production of the narcotic drugs known as hashish, charras, bhang, and ganja. Some fiber is obtained, especially from the staminate plants, in the northern part of Kashmir, where the hemp grown for the production of charras is more like the fiber types than that grown for bhang farther south.

Plants grown by the Department of Agriculture at Washington from seed received from the Botanical Garden at Sibpur, Calcutta, India, agreed almost perfectly with the de-

scription of *Cannabis indica* [1] written by Lamarck more than a century ago. (Pl. XLII, fig. 2.) They were distinctly different in general appearance from any of the numerous forms grown by this department from seed obtained in nearly all countries where hemp is cultivated, but the differences in botanical characters were less marked. The Indian hemp differed from Kentucky hemp in its more densely branching habit, its very dense foliage, the leaves mostly alternate, 7 to 11 (usually 9) very narrow leaflets, and in its nearly solid stalk. It was imperfectly dicœcious, a character not observed in any other variety. Its foliage remained green until after the last leaves of even the pistillate plants of Kentucky hemp had withered and fallen. It was very attractive as an ornamental plant but of no value for fiber.

ARABIA AND AFRICA.

Hemp somewhat similar to that of India, but generally shorter, is cultivated in Arabia, northern Africa, and also by some of the natives in central and southern Africa for the production of the drug, but not for fiber. In Arabia it is called "takrousi," in Morocco "kief" or "kif," and in South Africa "dakkan." None of these plants is suitable for fiber production.

KENTUCKY.

Practically all of the hemp grown in the United States is from seed produced in Kentucky. The first hemp grown in Kentucky was of European origin, the seed having been brought to the colonies, especially Virginia, and taken from there to Kentucky. In recent years there has been practically no importation of seed from Europe. Remnants of the European types are occasionally found in the shorter, more densely branching stalks terminating in thick clusters of small leaves. These plants yield more seed and mature earlier than the more desirable fiber types introduced from China

Nearly all of the hemp now grown in Kentucky is of Chinese origin. Small packets of seed are received from American missionaries in China. These seeds are carefully cultivated for two or three generations in order to secure a sufficient quantity for field cultivation, and also to acclimate the plants to Kentucky conditions. Attempts to produce

[1] Lamarck. Encyclopedie, v. 1, p. 695, 1788.

fiber plants by sowing imported seed broadcast have not given satisfactory results. Seed of the second or third generation from China is generally regarded as most desirable. This Kentucky hemp of Chinese origin has long internodes, long, slender branches, opposite and nearly horizontal except the upper ones, large leaves usually drooping and not crowded, with the seeds in small clusters near the ends of the branches. Small, dark-colored seeds distinctly mottled are preferred by the Kentucky hemp growers. Under favorable conditions Kentucky hemp attains a height of 7 to 10 feet when grown broadcast for fiber and 9 to 14 feet when cultivated for seed.

IMPROVEMENT BY SEED INTRODUCTION.

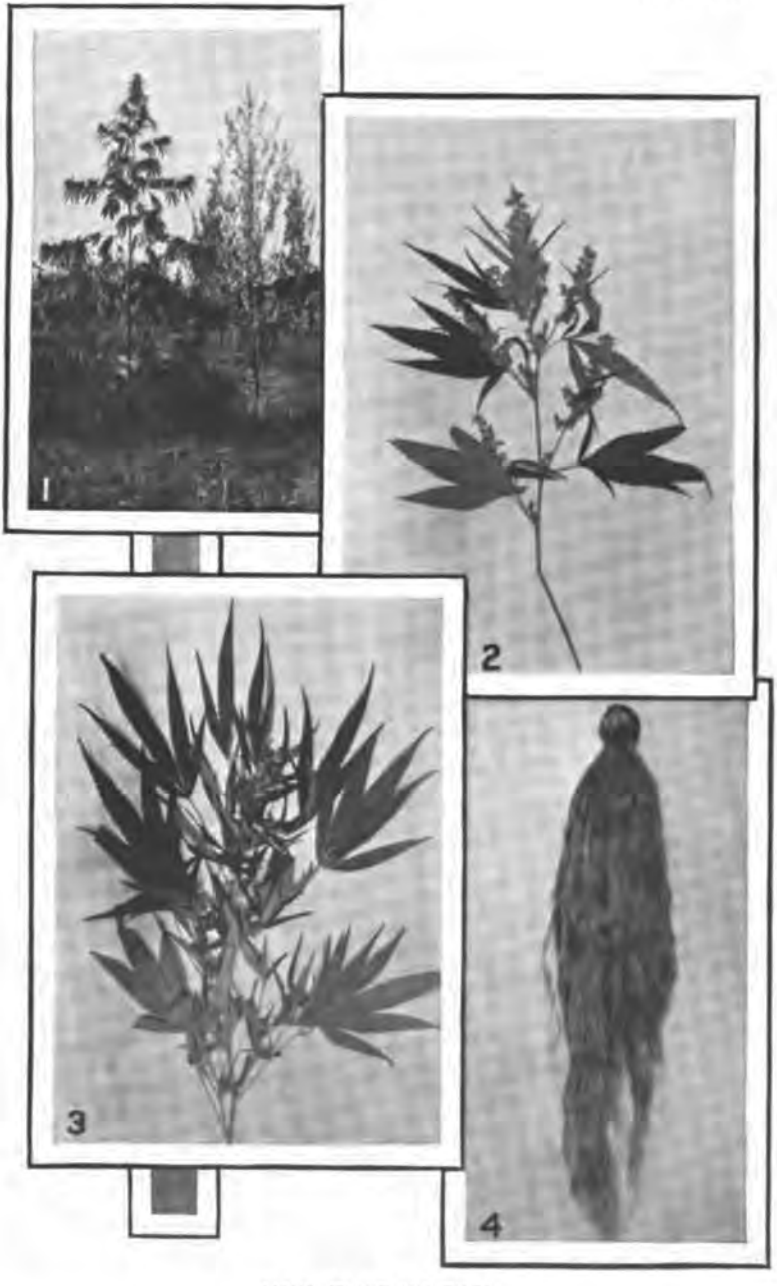
Without selection or continued efforts to maintain superior types, the hemp in Kentucky deteriorates. As stated by the growers, the hemp "runs out." The poorer types of plants for fiber are usually the most prolific seed bearers, and they are often earlier in maturing; therefore, without selection or roguing, the seed of these undesirable types increases more rapidly than that of the tall, late-maturing, better types which bear fewer seeds. New supplies of seed are brought from China to renew the stock. Owing to the confusion of names the seed received is not always of a desirable kind, and sometimes jute, China jute, or ramie seeds are obtained. When seed of the ta-ma variety is secured and is properly cultivated for two or three generations there is a marked improvement, but these improved strains run out in less than 10 years.

The numerous trials that have been made by the Department of Agriculture with hemp seed from nearly all of the sources mentioned and repeated introductions from the more promising sources indicate that little permanent improvement may be expected from mere introduction not followed by breeding and continued selection. In no instance, so far as observed, have any of the plants from imported seed grown as well the first year as the Kentucky hemp cultivated for comparison. Further introduction of seed in small quantities is needed to furnish stock for breeding and selection. The most promising varieties for introduction are ta-ma and shan-ma-tze, from China; Hiroshima and Tochigi, from Japan; Bologna, from Italy; and improved types from Hungary.

IMPROVEMENT BY SELECTION.

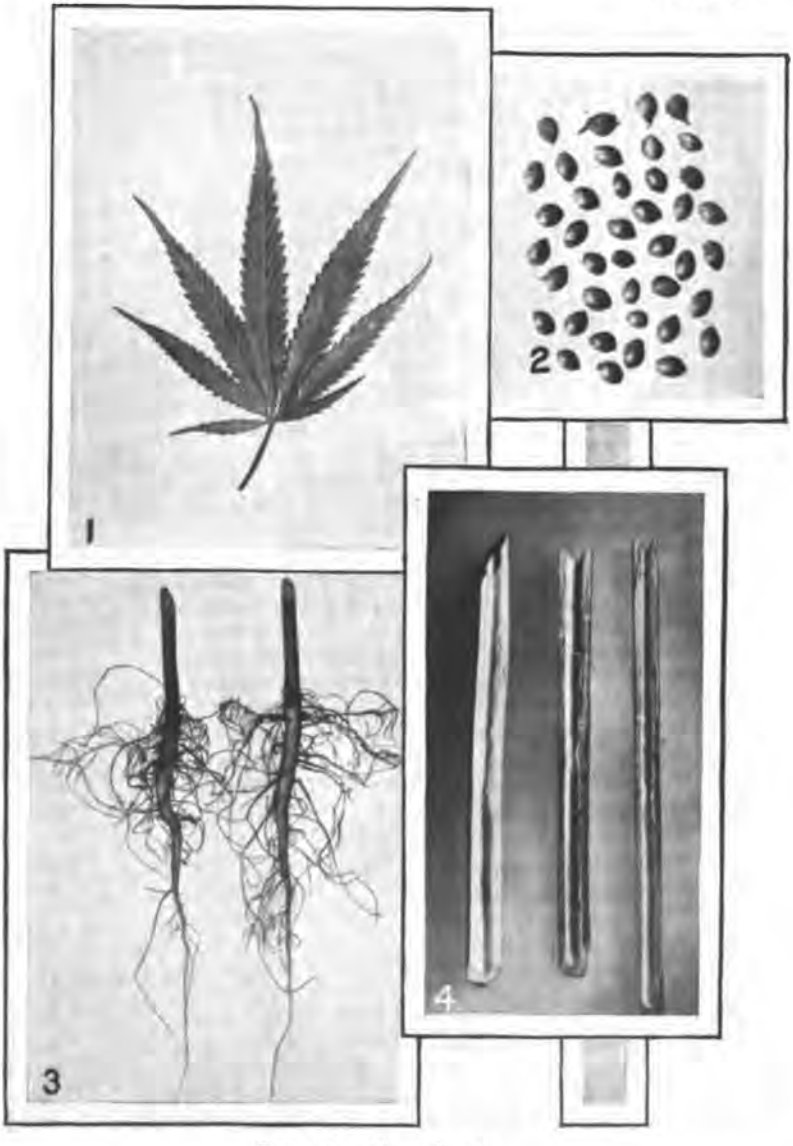
Kentucky hemp is reasonably uniform, not because of selection, or even grading the seeds, but because all types have become mixed together. Nearly all the seed is raised in a limited area. Hemp being cross-fertilized, it is more difficult to keep distinct types separate than in the case of wheat, flax, or other crops with self-pollinated flowers, but it is merely necessary to isolate the plants cultivated for seed and then exercise care to prevent the seed from becoming mixed. Until 1903 no well-planned and continued effort seems to have been undertaken in this country to produce an improved variety of hemp. At that time the results of breeding by careful selection improved varieties of wheat and flax at the Minnesota Agricultural Experiment Station were beginning to yield practical returns to the farmers of that State. Mr. Fritz Knorr, from Kentucky, then a student in the Minnesota College of Agriculture, was encouraged to take up the work with hemp. Seed purchased from a dealer in Nicholasville, Ky., was furnished by the United States Department of Agriculture. The work of selection was continued until 1909 under the direction of Prof. C. P. Bull, agronomist at the station. Points especially noted in selecting plants from which to save seed for propagation were length of internode, thinness of shell, height, and tendency of the stems to be well fluted. The seasons there were too short to permit selection for plants taking a longer season for growth. The improved strain of hemp thus developed was called Minnesota No. 8. Seed of this strain sown at the experiment station at Lexington, Ky., in 1910 and 1911 produced plants more uniform than those from unselected Kentucky seed, and the fiber was superior in both yield and quality. A small supply of this seed, grown by the Department of Agriculture at Washington, D. C., in 1912, was distributed to Kentucky hemp-seed growers in 1913, and in every instance the resulting seed plants were decidedly superior to those from ordinary Kentucky seed.

Seed selection is practiced to a limited extent on some of the best hemp-seed farms in Kentucky. Before the seed-hemp plants are cut the grower goes through the field and marks the plants from which seed is to be saved for the seed crop of the following year. Plants are usually selected for height, lateness, and length of internodes. Continued selec-



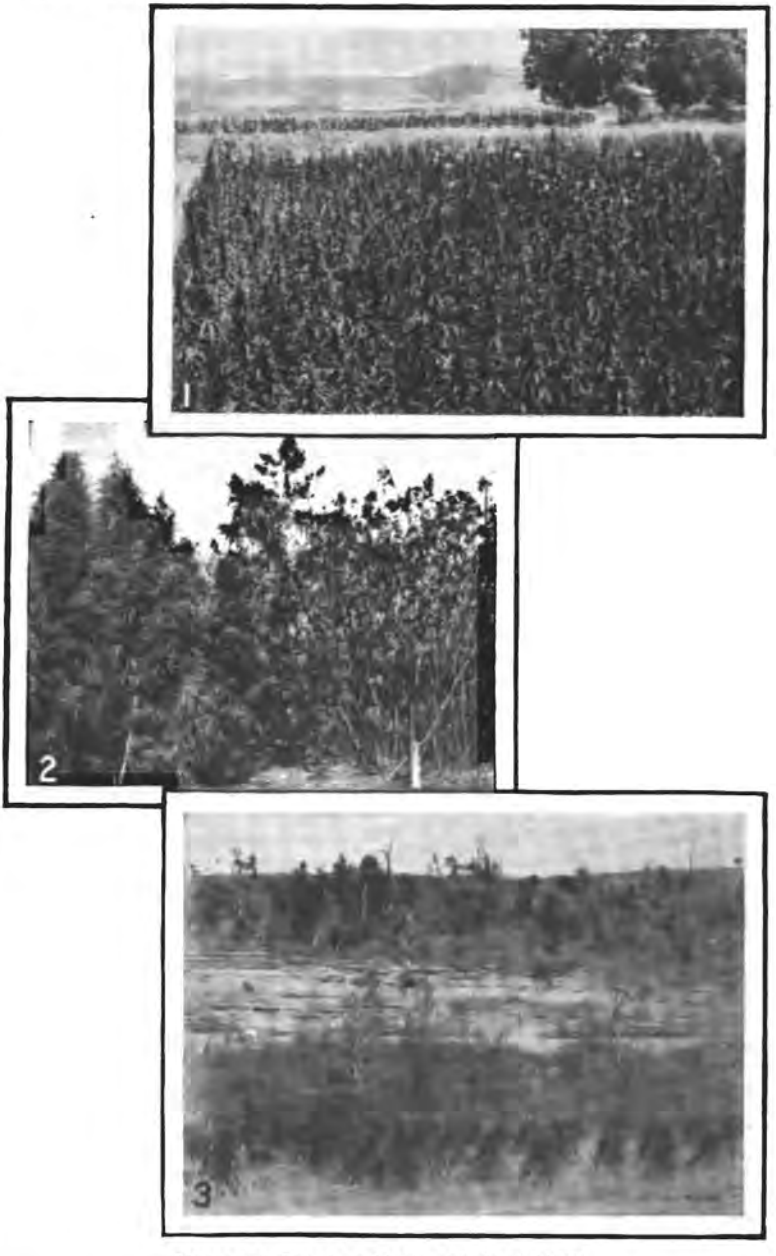
HEMP, PLANT AND FIBER.

Fig. 1.—Pistillate plant, left; staminate plant, right. Fig. 2.—Staminate flowers. Fig. 3.—Pistillate flowers. Fig. 4.—Fiber in the form in which it leaves the farm.



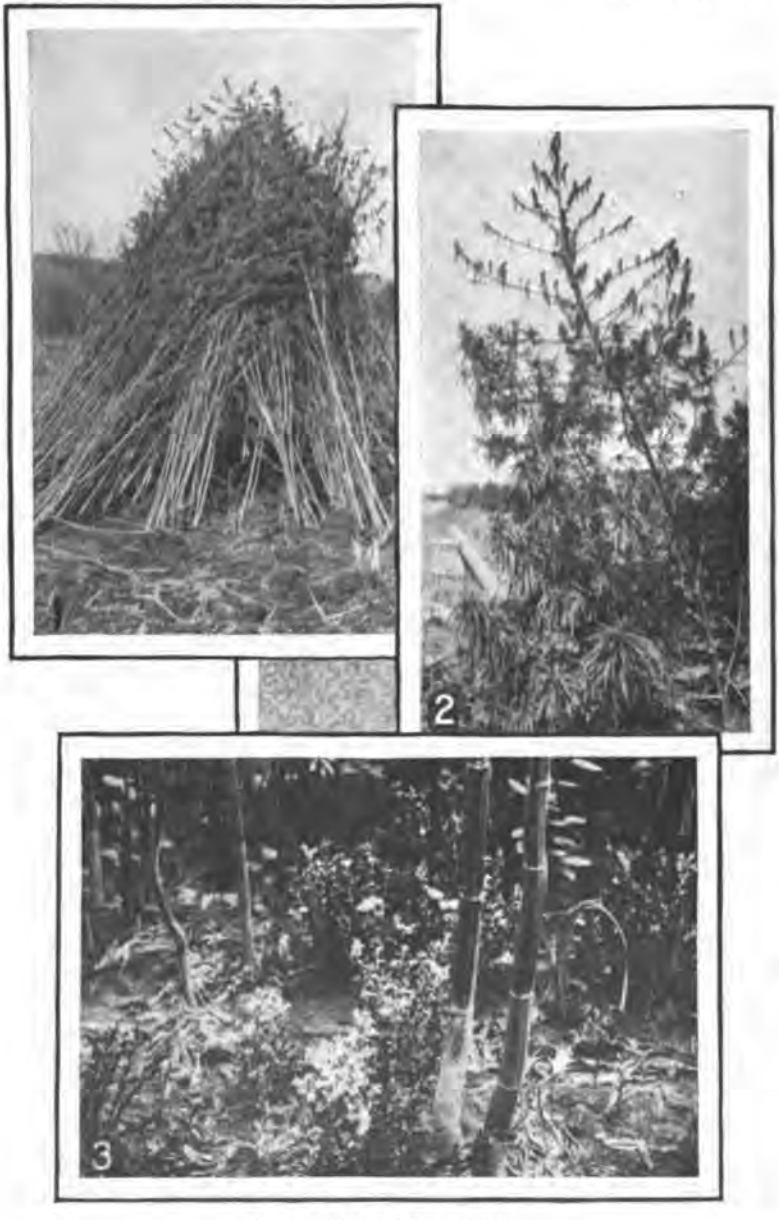
DETAILS OF HEMP PLANT.

Fig. 1.—Leaf, one-third natural size. Fig. 2.—Seeds, natural size. Fig. 3.—Roots, showing strong taproot. Fig. 4.—Sections of stalk, showing woody shell slightly thickened at the nodes.



DIFFERENT TYPES OF HEMP AND SEED HEMP.

Fig. 1.—Manchurian oil-seed hemp. Fig. 2.—India drug-producing hemp on left; Kentucky fiber-producing hemp in seed rows on right. Fig. 3.—Hemp-seed field in Kentucky River Valley, walled in with ledges of lime rock.



SEED HEMP AND MALADIES.

Fig. 1.—Shock of seed hemp curing. Fig. 2.—Seed-hemp plant attacked by fungus disease. Fig. 3.—Branched broom rape, parasitic on hemp roots.

tion in this manner will improve the type. Without selection continued each season, the general average of the crop deteriorates.

CLIMATE.

Hemp requires a humid temperate climate, such as that throughout the greater part of the Mississippi Valley. It has been grown experimentally as far north as Saskatoon, in northwestern Canada, and as far south as New Orleans, La., and Brunswick, Ga.

TEMPERATURE.

The best fiber-producing types of hemp require about four months free from killing frosts for the production of fiber and about five and one-half months for the full maturity of the seeds. The climatic conditions during the four months of the hemp-growing season in the region about Lexington, Ky., are indicated by the following table:

Temperature and rainfall in the hemp-growing region of Kentucky.[1]

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount driest year.	Total amount wettest year.
	°F.	°F.	°F.	Inches.	Inches.	Inches.
May	64	91	32	3.6	2.7	4.7
June	73	95	42	4.2	3.7	7.4
July	76	102	51	4.0	2.6	3.1
August	75	96	51	3.8	3.7	7.3
Mean for 4 months	72	.....	.....	3.9	.....	.....
Annual mean	55	.....	.....	42.5	.....	.....

[1] Henry, Alfred Judson. Climatology of the United States. U. S. Department of Agriculture, Weather Bureau, Bulletin Q, p. 762, 1906.

Hemp grows best where the temperature ranges between 60° and 80° F., but it will endure colder and warmer temperatures. Young seedlings and also mature plants will endure with little injury light frosts of short duration. Young hemp is less susceptible than oats to injury from frost, and fields of hemp ready for harvest have been uninjured by frosts which ruined fields of corn all around them. Frosts are injurious to nearly mature plants cultivated for seed production.

RAINFALL.

Hemp requires a plentiful supply of moisture throughout its growing season, and especially during the first six weeks. After it has become well rooted and the stalks are 20 to 30 inches high it will endure drier conditions, but a severe drought hastens its maturity and tends to dwarf its growth. It will endure heavy rains, or even a flood of short duration, on light, well-drained soils, but on heavy, impervious soils excessive rain, especially when the plants are young, will ruin the crop.

In 1903, a large field of hemp on rich, sandy-loam soil of alluvial deposit, well supplied with humus, near Gridley, Cal., was flooded to a depth of 2 to 6 inches by high water in the Feather River. The hemp had germinated but a few days before and was only 1 to 3 inches high. The water remained on the land about three days. The hemp started slowly after the water receded, but in spite of the fact that there was no rain from this time, the last of March, until harvest, the last of August, it made a very satisfactory crop, 6 to 12 feet in height. The soil, of porous, spongy texture, remained moist below the dusty surface during the entire growing season.

An experimental crop of about 15 acres on impervious clay and silt of alluvial deposit, but lacking in humus, in eastern Louisiana was completely ruined by a heavy rain while the plants were small.

The total average rainfall during the four months of the hemp-growing season in Kentucky is 15.6 inches, as shown in the table on page 305, and this is distributed throughout the season. When there is an unusual drought in that region, as in 1913, the hemp is severely injured. It is not likely to succeed on upland soils in localities where corn leaves curl because of drought before the middle of August.

IRRIGATION.

In 1912, and again in 1913, crops of hemp were cultivated under irrigation at Lerdo, Cal. The soil there is an alluvial sandy loam of rather firm texture, but with good natural drainage and not enough clay to form a crust on the surface after flooding with water. The land is plowed deeply, leveled, and made up into irrigation blocks with low borders over which drills and harvesting machinery may easily work.

The seed is drilled in the direction of the fall, so that when flooded the water runs slowly down the drill furrows. Three irrigations are sufficient, provided the seed is sown early enough to get the benefit of the March rains. The fiber thus produced is strong and of good quality.

WEATHER FOR RETTING AND BREAKING.

Cool, moist weather, light snows, or alternate freezing and thawing are favorable for retting hemp. Dry weather, not necessarily free from rain but with a rather low relative humidity, is essential for satisfactory work in breaking hemp. The relative humidity at Lexington in January, February, and March, when most of the hemp is broken, ranges from 62 to 82 per cent. The work of breaking hemp is rarely carried on when there is snow on the ground. The work of collecting and cleaning hemp seed can be done only in dry weather.

SOIL.

SOILS IN THE HEMP-GROWING REGION OF KENTUCKY.

The soil in most of the hemp fields of Kentucky is of a yellowish clay loam, often very dark as a result of decaying vegetable matter, and most of it overlying either Lexington or Cincinnati limestone. There are frequent outcroppings of lime rock throughout the region. The soil is deep, fertile, well supplied with humus, and its mechanical condition is such that it does not quickly dry out or become baked and hard. The land is rolling, affording good natural drainage.

HEMP SOILS IN OTHER STATES.

In eastern Nebraska, hemp has been grown on a deep clay-loam prairie soil underlain with lime rock. In some of the fields there are small areas of gumbo soil, but hemp does not grow well on these areas. In California, hemp is cultivated on the reclaimed lands of alluvial deposits in the lower valley of the Sacramento River. This is a deep soil made up of silt and sand and with a very large proportion of decaying vegetable matter. These rich, alluvial soils, which are never subject to drought, produce a heavier growth of hemp than the more shallow upland soils in Kentucky. In Indiana, crops of hemp have been grown in the Kankakee Valley on peaty soils overlying marl or yellow clay containing an abundance of lime. These lands have

been drained by large, open ditches. There is such a large proportion of peat in the soil that it will burn for months if set on fire during the dry season, yet this soil contains so much lime that when the vegetation is cleared away Kentucky bluegrass comes in rather than sedges. It is an alkaline rather than an acid soil. The large amount of peat gives these soils a loose, spongy texture, well adapted to hold moisture during dry seasons. Water remains in the ditches 6 to 10 feet below the surface nearly all summer, and the hemp crops have not been affected by the severe drought which has injured other crops on the surrounding uplands. In southeastern Pennsylvania, and in Indiana, Wisconsin, and Minnesota, the best crops, producing the largest yields of fiber and fiber of the best quality, have been grown on clay-loam upland soils. In some instances, however, the upland crops have suffered from drought.

SOILS SUITED TO HEMP.

Hemp requires for the best development of the plant, and also for the production of a large quantity and good quality of fiber, a rich, moist soil having good natural drainage, yet not subject to severe drought at any time during the growing season. A clay loam of rather loose texture and containing a plentiful supply of decaying vegetable matter or an alluvial deposit alkaline and not acid in reaction should be chosen for this crop.

SOILS TO BE AVOIDED.

Hemp will not grow well on stiff, impervious, clay soils, or on light sandy or gravelly soils. It will not grow well on soils that in their wild state are overgrown with either sedges or huckleberry bushes. These plants usually indicate acid soils. It will make only a poor growth on soils with a hardpan near the surface or in fields worn out by long cultivation. Clay loams or heavier soils give heavier yields of strong but coarser fiber than are obtained on sandy loams and lighter soils.

EFFECT OF HEMP ON THE LAND.

Hemp cultivated for the production of fiber, cut before the seeds are formed and retted on the land where it has been grown, tends to improve rather than injure the soil. It improves its physical condition, destroys weeds, and does not exhaust its fertility.

PHYSICAL CONDITION.

Hemp loosens the soil and makes it more mellow. The soil is shaded by hemp more than by any other crop. The foliage at the top of the growing plants makes a dense shade and, in addition, all of the leaves below the top fall off, forming a mulch on the ground, so that the surface of the soil remains moist and in better condition for the action of soil bacteria. The rather coarse taproots (Pl. XLI, fig. 3), penetrating deeply and bringing up plant food from the subsoil, decay quickly after the crop is harvested and tend to loosen the soil more than do the fibrous roots of wheat, oats, and similar broadcast crops. Land is more easily plowed after hemp than after corn or small grain.

HEMP DESTROYS WEEDS.

Very few of the common weeds troublesome on the farm can survive the dense shade of a good crop of hemp. If the hemp makes a short, weak growth, owing to unsuitable soil, drought, or other causes, it will have little effect in checking the growth of weeds, but a good, dense crop, 6 feet or more in height, will leave the ground practically free from weeds at harvest time. In Wisconsin, Canada thistle has been completely killed and quack-grass severely checked by one crop of hemp. In one 4-acre field in Vernon County, Wis., where Canada thistles were very thick, fully 95 per cent of the thistles were killed where the hemp attained a height of 5 feet or more, but on a dry, gravelly hillside in this same field where it grew only 2 to 3 feet high, the thistles were checked no more than they would have been in a grain crop. Some vines, like the wild morning-glory and bindweed climb up the hemp stalks and secure light enough for growth, but low-growing weeds can not live in a hemp field.

HEMP DOES NOT EXHAUST THE FERTILITY OF THE SOIL.

An abundant supply of plant food is required by hemp, but most of it is merely borrowed during development and returned to the soil at the close of the season. The amounts of the principal fertilizing elements contained in mature crops of hemp, as compared with other crops, are shown in the accompanying table.

Amounts of principal fertilizing elements in an acre of hemp, corn, wheat, oats, sugar beets, and cotton.

Crops.	Nitrogen.	Phosphoric acid.	Potassium.
	Pounds.	*Pounds.*	*Pounds.*
Hemp (yielding 1,000 pounds of clean fiber) [1]	62.7	33.2	101.3
Corn (50 bushels and 1½ tons of stover) [2]	74.0	11.5	35.5
Wheat (25 bushels of grain, 1½ tons of straw) [2]	48.0	8.0	24.0
Oats (50 bushels of grain, 1½ tons of straw) [2]	48.5	8.0	34.0
Sugar beets (20 tons of roots) [2]	100.0	18.0	157.0
Cotton (yielding 400 pounds of lint) [1]	29.2	22.5	35.3

[1] Jaffa, M. E. Composition of the Ramie Plant. California Experiment Station Bulletin, p. 94, 1891.

[2] Hopkins, Cyril G., and Pettit, James H. The Fertility in Illinois Soils. Illinois Experiment Station Bulletin 123, p. 189, 1908.

The data in the table indicate that hemp requires for its best development a richer soil than any of the other crops mentioned except sugar beets. These other crops, except the stalks of corn and the tops of beets, are entirely removed from the land, thus taking away nearly all the plant food consumed in their growth. Only the fiber of hemp is taken away from the farm and this is mostly cellulose, composed of water and carbonic acid.

The relative proportions by weight of the different parts of the hemp plant, thoroughly air dried, are approximately as follows: Roots 10 per cent, stems 60 per cent, and leaves 30 per cent.[1] The mineral ingredients of these different parts of the hemp plant are shown in the following table:

Ash ingredients of the leaves, stalks, and roots of the hemp plant, carbonic acid excluded, 100 parts dried material in each case.[1]

Ingredients.	Leaves.	Stalks.	Roots.
Lime	4.992	0.949	0.713
Magnesia	.585	.194	.291
Potash	2.858	1.659	1.829
Soda	.024		
Phosphoric acid	.947	.447	.531
Sulphuric acid	.226	.040	.047
Chlorin	.017	.019	.014
Silica	.575	.035	.077
Percentage of ash	10.224	3.343	3.502

[1] Peter, Robert. Chemical Examination of the Ash of Hemp and Buckwheat Plants. Kentucky Geological Survey, p. 12, 1884.

The foliage, constituting nearly one-third of the weight of the entire plant and much richer in essential fertilizing elements than the stalks, all returns to the field where the hemp grows. The roots also remain and, together with the stubble, they constitute more than 10 per cent of the total weight and contain approximately the same proportions of fertilizing elements as the stalks. The leaves and roots therefore return to the soil nearly two-thirds of the fertilizing elements used in building up the plant.

After the hemp is harvested it is spread out on the same land for retting. In this retting process nearly all of the soluble ingredients are washed out and returned to the soil. When broken in the field on small hand brakes, as is still the common practice in Kentucky, the hurds, or central woody portion of the stalk, together with most of the outer bark, are left in small piles and burned, returning the mineral ingredients to the soil. Where machine brakes are used the hurds may serve an excellent purpose as an absorbent in stock yards and pig pens, to be returned to the fields in barnyard manure.

The mineral ingredients permanently removed from the farm are thus reduced to the small proportions contained in the fiber. These proportions, calculated in pounds per acre and compared with the amounts removed by other crops, are shown in the following table:

Mineral ingredients removed from the soil by hemp, wheat, corn, and tobacco, calculated in pounds per acre.[1]

Ingredients.	Hemp fiber: In 800 pounds.	Wheat: In 20 bushels.	Corn: In 50 bushels.	Tobacco, including stalks: In 1,000 pounds.
Lime	7.872	1.63	0.22	68.00
Magnesia	1.128	2.43	3.61	8.67
Potash	.968	5.45	8.06	69.73
Soda	.096	.13	6.22	6.80
Phosphoric acid	2.080	9.12	11.85	8.13
Sulphuric acid	.232	.08	(2)	8.40
Chlorin	.016	.35	(2)	1.06
Silica	.736	.41	.71	5.86
Total ash	13.128	19.60	30.67	176.65

[1] Peter, Robert. Chemical Examination of the Ash of Hemp and Buckwheat Plants. Kentucky Geological Survey, p. 17, 1884.

[2] Not estimated.

The hemp fiber analyzed was in the ordinary condition as it leaves the farm. When washed with cold water, removing some but not all of the dirt, the ashy residue was reduced more than one-third, and the total earthy phosphates were reduced nearly one-half. The amount of plant food actually removed from the soil by hemp is so small as to demand little attention in considering soil exhaustion. The depletion of the humus is the most important factor, but even in this respect hemp is easier on the land than other crops except clover and alfalfa. The fact that hemp is often grown year after year on the same land for 10 to 20 years, with little or no application of fertilizer and very little diminution in yield, is evidence that it does not exhaust the soil.

ROTATION OF CROPS.

In Kentucky, hemp is commonly grown year after year on the same land without rotation. It is the common practice in that State to sow hemp after bluegrass on land that has been in pasture for many years, or sometimes it is sown as the first crop on recently cleared timberland. It is then sown year after year until it ceases to be profitable or until conditions favor the introduction of other crops. On the prairie soils in eastern Nebraska and also on the peaty soils in northern Indiana, more uniform crops were obtained after the first year. On some of the farms in California hemp is grown in rotation with beans. Hemp is recommended to be grown in rotation with other farm crops on ordinary upland soils suited to its growth. In ordinary crop rotations it would take about the same place as oats. If retted on the same land, however, it would occupy the field during the entire growing season, so that it would be impossible to sow a field crop after hemp unless it were a crop of rye. The growing of rye after hemp has been recommended in order to prevent washing and to retain the soluble fertilizing elements that might otherwise be leached out during the winter. This recommendation, however, has not been put in practice sufficiently to demonstrate that it is of any real value. Hemp will grow well in a fertile soil after any crop, and it leaves the land in good condition for any succeeding crop. Hemp requires a plentiful supply of fertilizing elements, especially nitrogen, and it is therefore best

to have it succeed clover, peas, or grass sod. If it follows wheat, oats, or corn, these crops should be well fertilized with barnyard manure. The following crop rotations are suggested for hemp on fertile upland soils:

First year.	Second year.	Third year.	Fourth year.	Fifth year.
Hemp	Corn	Wheat	Clover	Grass and pasture.
Do	Sugar beets, potatoes, or onions.	...do	.....do	Do.
Corn	Peas or beans	Hemp	Barley or oats	Clover.

Hemp leaves the ground mellow and free from weeds and is therefore recommended to precede sugar beets, onions, celery, and similar crops which require hand weeding. If hemp is grown primarily to kill Canada thistle, quack-grass, or similar perennial weeds, it may be grown repeatedly on the same land until the weeds are subdued.

FERTILIZERS.

Hemp requires an abundant supply of plant food. Attaining in four months a height of 6 to 12 feet and producing a larger amount of dry vegetable matter than any other crop in temperate climates, it must be grown on a soil naturally fertile or enriched by a liberal application of fertilizer. In Europe and in Asia heavy applications of fertilizers are used to keep the soils up to the standard for growing hemp, but in the United States most of the hemp is grown on lands the fertility of which has not been exhausted by centuries of cultivation. In Kentucky, where the farms are well stocked with horses and cattle, barnyard manure is used to maintain the fertility of the soils, but it is usually applied to other crops and not directly to hemp. In other States no fertilizer has been applied to soils where hemp is grown, except in somewhat limited experiments.

BARNYARD MANURE.—The best single fertilizer for hemp is undoubtedly barnyard manure. It supplies the three important plant foods, nitrogen, potash, and phosphoric acid, and it also adds to the store of humus, which appears to be more necessary for hemp than for most other farm crops. If other fertilizers are used, it is well to apply barnyard manure also, but it should be applied to the preceding crop,

or, at the latest, in the fall before the hemp is sown. It must be well rotted and thoroughly mixed with the soil before the hemp seed is sown, so as to promote a uniform growth of the hemp stalks. Uniformity in the size of the plants of other crops is of little consequence, but in hemp it is a matter of prime importance. An application of coarse manure in the spring, just before sowing, is likely to result in more injury than benefit. The amount that may be applied profitably will vary with different soils. There is little danger, however, of inducing too rank a growth of hemp on upland soils, provided the plants are uniform, for it must be borne in mind that stalk and not fruit is desired. On soils deficient in humus as the result of long cultivation, the increased growth of hemp may well repay for the application of 15 to 20 tons of barnyard manure per acre. It would be unwise to sow hemp on such soils until they had been heavily fertilized with barnyard manure.

COMMERCIAL FERTILIZERS.—On worn-out soils, peaty soils, and possibly on some alluvial soils, commercial fertilizers may be used with profit in addition to barnyard manure. The primary effect to be desired from commercial fertilizers on hemp is a more rapid growth of the crop early in the season. This rapid early growth usually results in a greater yield and better quality of fiber. The results of a series of experiments conducted at the agricultural experiment station at Lexington, Ky., in 1889 led to the following conclusions:[1]

(1) That hemp can be raised successfully on worn bluegrass soils with the aid of commercial fertilizers.

(2) That both potash and nitrogen are required to produce the best results.

(3) That the effect was the same, whether muriate or sulphate was used to furnish potash.

(4) That the effect was about the same, whether nitrate of soda or sulphate of ammonia was used to furnish nitrogen.

(5) That a commercial fertilizer containing about 6 per cent of available phosphoric acid, 12 per cent of actual potash, and 4 per cent of nitrogen (mostly in the form of nitrate of soda or sulphate of ammonia) would be a good fertilizer for trial.

The increased yield and improved quality of the fiber on the fertilized plats compared with the yield from the check plat, not fertilized, in these experiments would warrant the

[1] Scovel, M. A. Effect of Commercial Fertilizers on Hemp. Kentucky Agricultural Experiment Station, Bulletin 27, p. 3, 1890.

application of nitrogen at the rate of 160 pounds of nitrate of soda or 120 pounds of sulphate of ammonia per acre, and potash at the rate of about 160 pounds of either sulphate or muriate of potash per acre.

On the rich alluvial soils reclaimed by dikes from the Sacramento River at Courtland, Cal., Mr. John Heaney has found that an application of nitrate of soda at the rate of not more than 100 pounds per acre soon after sowing and again two weeks to a month later, or after the first application has been washed down by rains, will increase the yield and improve the quality of the fiber.

LEGUMINOUS CROPS OR GREEN MANURE.—Beans grown before hemp and the vines returned to the land and plowed under have given good results in increased yield and improved quality of fiber on alluvial soils at Courtland, Cal. Clover is sometimes plowed under in Kentucky to enrich the land for hemp. It must be plowed under during the preceding fall, so as to become thoroughly rotted before the hemp is grown.

HEMP AS A GREEN MANURE.—In experiments with various crops for green manure for wheat in India, hemp was found to give the best results.[1] In exceptionally dry seasons, as in 1908 and 1913, many fields of hemp do not grow high enough to be utilized profitably for fiber production. They are often left until fully mature and then burned. Better results would doubtless be obtained if the hemp were plowed under as soon as it could be determined that it would not make a sufficient growth for fiber production. Mature hemp stalks or dry hurds should not be plowed under, because they rot very slowly

DISEASES, INSECTS, AND WEEDS.

Hemp is remarkably free from diseases caused by fungi. In one instance at Havelock, Nebr., in a low spot where water had stood, nearly 3 per cent of the hemp plants were dead. The roots of these dead plants were pink in color and a fungous mycelium was found in them, but it was not in a stage of development to permit identification. The fungus was probably not the primary cause of the trouble, since the dead plants were confined to the low place and

[1] Report of Cawnpore Agricultural Station, United Provinces, India, for 1908, p. 12.

there was no recurrence of the disease on hemp grown in the same field the following year.

A fungus described under the name *Dendrophoma marconii* Cav. was observed on hemp in northern Italy in 1887.[1] This fungus attacked the plants after they were mature enough to harvest for fiber. Its progress over the plant attacked and also the distribution of the infection over the field were described as very rapid, but if the disease is discovered at its inception and the crop promptly harvested it causes very little damage.

In the fall of 1913 a disease was observed on seed hemp grown by the Department of Agriculture at Washington. (Pl. XLIII, fig. 2.) It did not appear until after the stage of full flowering of the staminate plants and therefore after the stage for harvesting for fiber. A severe hailstorm had bruised the plants and broken the bark, doubtless making them more susceptible to the disease. The first symptoms noted in each plant attacked were wilted leaves near the ends of branches above the middle of the plant, accompanied by an area of discolored bark on the main stalk below the base of each diseased branch. In warm, moist weather the disease spread rapidly, killing a plant 10 feet high in five days and also infesting other plants. It was observed only on pistillate plants, but the last late-maturing staminate plants left in the plat after thinning the earlier ones were cut soon after the disease was discovered.[2]

In a few instances insects boring in the stems have killed some plants, but the injury caused in this manner is too small to be regarded as really troublesome.

Cutworms have caused some damage in the late-sown hemp in land plowed in the spring, but there is practically no danger from this source in hemp sown at the proper season and in fall-plowed land well harrowed before sowing.

A Chilean dodder (*Cuscuta racemosa*) troublesome on alfalfa in northern California was found on the hemp at Gridley, Cal., in 1903. Although it was abundant in some parts of the field at about the time the hemp was ready for harvest, it did not cause any serious injury.

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[1] Cavara, Fridiano. Appunti di Patologia Vegetal. Atti dell' Instituto Botanico dell' Universitá di Pavia, s. 2, v. 1, p. 425, 1888.

[2] This fungus was not in a stage permitting identification, but cultures for further study were made in the Laboratory of Plant Pathology.

Black bindweed (*Polygonum convolvulus*) and wild morning-glory (*Convolvulus sepium*) sometimes cause trouble in low, rich land by climbing up the plants and binding them together.

The only really serious enemy to hemp is branched broom rape (*Orobanche ramosa*). (Pl. XLIII, fig. 3.) This is a weed 6 to 15 inches high, with small, brownish yellow, scalelike leaves and rather dull purple flowers. The entire plant is covered with sticky glands which catch the dust and give it a dirty appearance. Its roots are parasitic on the roots of hemp. It is also parasitic on tobacco and tomato roots.[1] Branched broom rape is troublesome in Europe and the United States, but is not known in Asia. Its seeds are very small, about the size of tobacco seed, and they stick to the gummy calyx surrounding the hemp seed when the seed-hemp plants are permitted to fall on the ground in harvesting. There is still more opportunity for them to come in contact with the seed of hemp grown for fiber. The broom rape is doubtless distributed more by means of lint seed (seed from overripe fiber hemp) than by any other means. When broom rape becomes abundant it often kills a large proportion of the hemp plants before they reach maturity. As a precaution it is well to sow only well-cleaned seed from cultivated hemp and insist on a guaranty of no lint seed. If the land becomes infested, crops other than hemp, tobacco, tomatoes, or potatoes should be grown for a period of at least seven years. The seeds retain their vitality several years.[2]

HEMP-SEED PRODUCTION.

All of the hemp seed used in the United States for the production of hemp for fiber is produced in Kentucky. Nearly all of it is obtained from plants cultivated especially for seed production and not for fiber. The plants cultivated for seed for the fiber crop are of the fiber-producing type and not the type commonly obtained in bird-seed hemp. Old stocks of hemp seed of low vitality are often sold for bird seed, but much of the hemp seed sold by seedsmen or dealers in bird supplies is of the densely branching Smyrna type.

[1] Garman, H. The Broom-Rape of Hemp and Tobacco. Kentucky Agricultural Experiment Station, Bulletin 24, p. 16, 1890.

[2] Garman, H. The Broom-Rapes. Kentucky Agricultural Experiment Station, Bulletin 105, p. 14, 1903.

LINT SEED.

In some instances seed is saved from hemp grown for fiber but permitted to get overripe before cutting. This is known as lint seed. It is generally regarded as inferior to seed from cultivated plants. A good crop is sometimes obtained from lint seed, but it is often lacking in vigor as well as germinative vitality, and it is rare that good crops are obtained from lint seed of the second or third generation.

CULTIVATED SEED.

Nearly all of the cultivated seed is grown in the valley of the Kentucky River and along the creeks tributary to this river for a distance of about 50 miles above High Bridge. The river through this region flows in a deep gorge about 150 feet below the general level of the land. The sides of this valley are steep, with limestone outcropping, and in some places perpendicular ledges of lime rock in level strata. (Pl. XLII, fig. 3.) The river, which overflows every spring, almost covering the valley between the rocky walls, forms alluvial deposits from a few rods to half a mile in width. The seed hemp is grown on these inundated areas, and especially along the creeks, where the water from the river backs up, leaving a richer deposit of silt than along the banks of the river proper, where the deposited soils are more sandy. There is a longer season free from frost in these deep valleys than on the adjacent highlands. Instead of having earlier frosts in the fall, as may be usually expected in lowlands, the valley is filled with fog on still nights, thus preventing damage from frost. For the production of hemp seed a rich, alluvial soil containing a plentiful supply of lime and also a plentiful supply of moisture throughout the growing season is necessary. The crop also requires a long season for development. The young seedlings will endure light frosts without injury, but a frost before harvest will nearly ruin the crop. A period of dry weather is necessary after the harvest in order to beat out and clean the seeds.

PREPARATION OF LAND.

The land is plowed as soon as possible after the spring floods, which usually occur in February and early in March.

After harrowing, it is marked in checks about 4 or 5 feet each way. Hemp cultivated for seed production must have room to develop branches. (Pl. XL, fig. 1.)

PLANTING.

The seed is planted between the 20th of March and the last of April—usually earlier than the seed is sown for the production of fiber. It is usually planted by hand, 5 to 7 seeds in a hill, and covered with a hoe. In some instances planters are used, somewhat like those used for planting corn, and on some farms seeders are used which plant 1 or 2 drills at a time 4 or 5 feet apart. When planted in drills it is usually necessary to thin out the plants afterwards. One or two quarts of seed are sufficient to plant an acre. Less than one quart would be sufficient if all the plants were allowed to grow.

CULTIVATION.

On the best farms the crop is cultivated four times—twice rather deep and twice with cultivators with fine teeth, merely stirring the surface. When the first flowers are produced, so that the staminate plants may be recognized, all of these plants are cut out except about one per square rod. These will produce sufficient pollen to fertilize the flowers on the pistillate, or seed-bearing plants, and the removal of the others will give more room for the development of the seed-bearing plants.

HARVEST.

The seed-bearing plants are allowed to remain until fully mature, or as long as possible without injury from frost. They are cut with corn knives, usually during the first half of October, leaving the stubble 10 to 20 inches high. The plants are set up in loose shocks around one or two plants which have been left standing. The shocks are usually bound near the top with binder twine. They are left in this manner for two or three weeks, until thoroughly dry. (Pl. XLIII, fig. 1.)

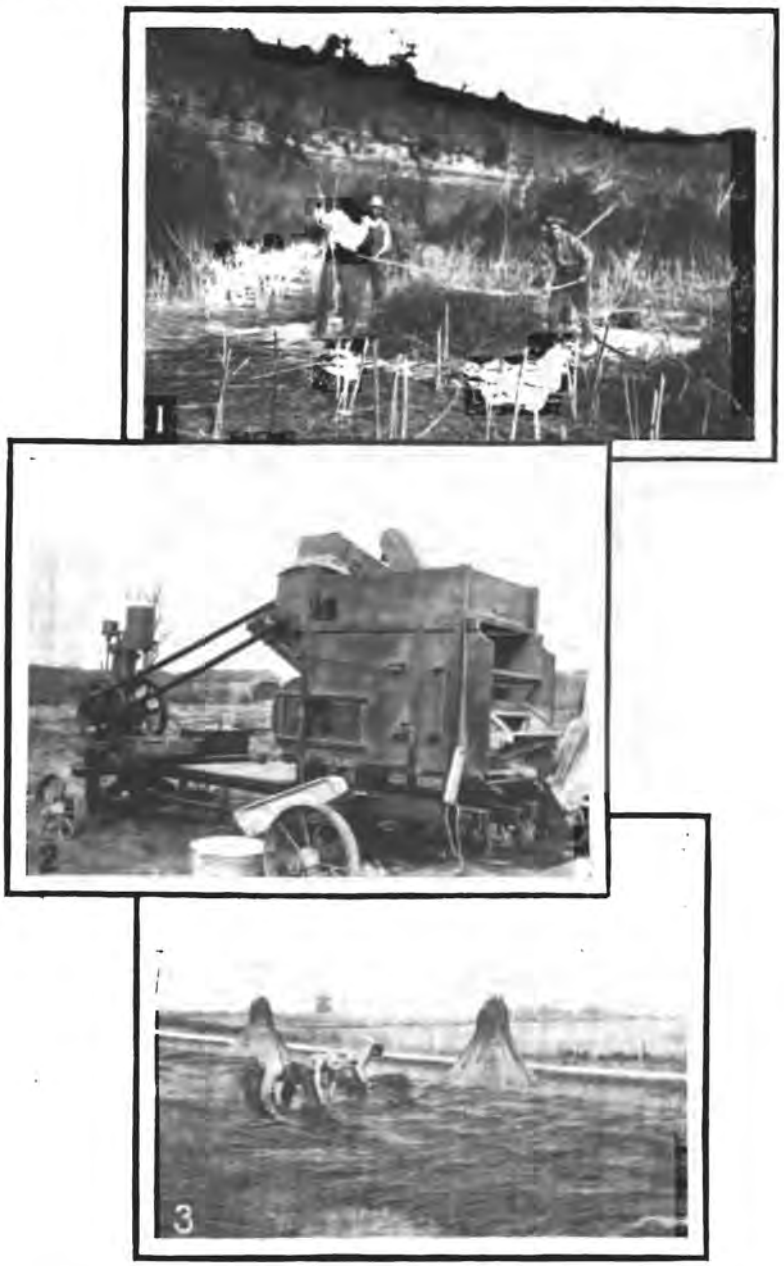
COLLECTING THE SEED.

When the seed hemp is thoroughly dry, men (usually in gangs of five or six, with tarpaulins about 20 feet square) go

into the field. One man with an ax cuts off the hemp stubble between four shocks and clears a space large enough to spread the tarpaulin. The other men pick up an entire shock and throw it on the tarpaulin. They then beat off the seeds with sticks about 5 feet long and 1½ inches in diameter. (Pl. XLIV, fig. 1.) When the seed has been beaten off from one side of the shock the men turn it over by means of the sticks, and after beating off all of the seed they pick up with the sticks the stalks in one bunch and throw them off the canvas, and then treat another shock in the same manner. They will beat off the seed from four shocks in 15 to 20 minutes, securing 2 or 3 pecks of seed from each shock. While this seems a rather crude way of collecting the seed, it is doubtless the most economical and practical method that may be devised. The seed falls so readily from the dry hemp stalks that it would be impossible to move them without a very great loss. Furthermore, it would be very difficult to handle plants 10 to 14 feet high, with rigid branches 3 to 6 feet in length, so as to feed them to any kind of thrashing machine.

CLEANING THE SEED.

The seed and chaff which have been beaten on the tarpaulin are sometimes beaten or tramped to break up the coarser bunches and stalks, and in some instances they are rubbed through coarse sieves in order to reduce them enough to be put through a fanning mill. The seed is then partly cleaned by a fanning mill in the field and afterwards run once or twice through another mill with finer sieves and better adjustments of fans. Even after this treatment it is usually put through a seed-cleaning machine by the dealers. There has recently been introduced on some of the best seed-hemp farms a kind of homemade thrashing machine, consisting essentially of a feeding device, cylinder, and concaves, attached to a rather large fanning mill, all being driven by a gasoline engine. (Pl. XLIV, fig. 2.) The hemp seed is fed to this machine just as it comes from the tarpaulin after beating off from the shock. It combines the process of breaking up the chaff into finer pieces and the work of fanning the seed in the field, and it performs this work more effectively and more rapidly.

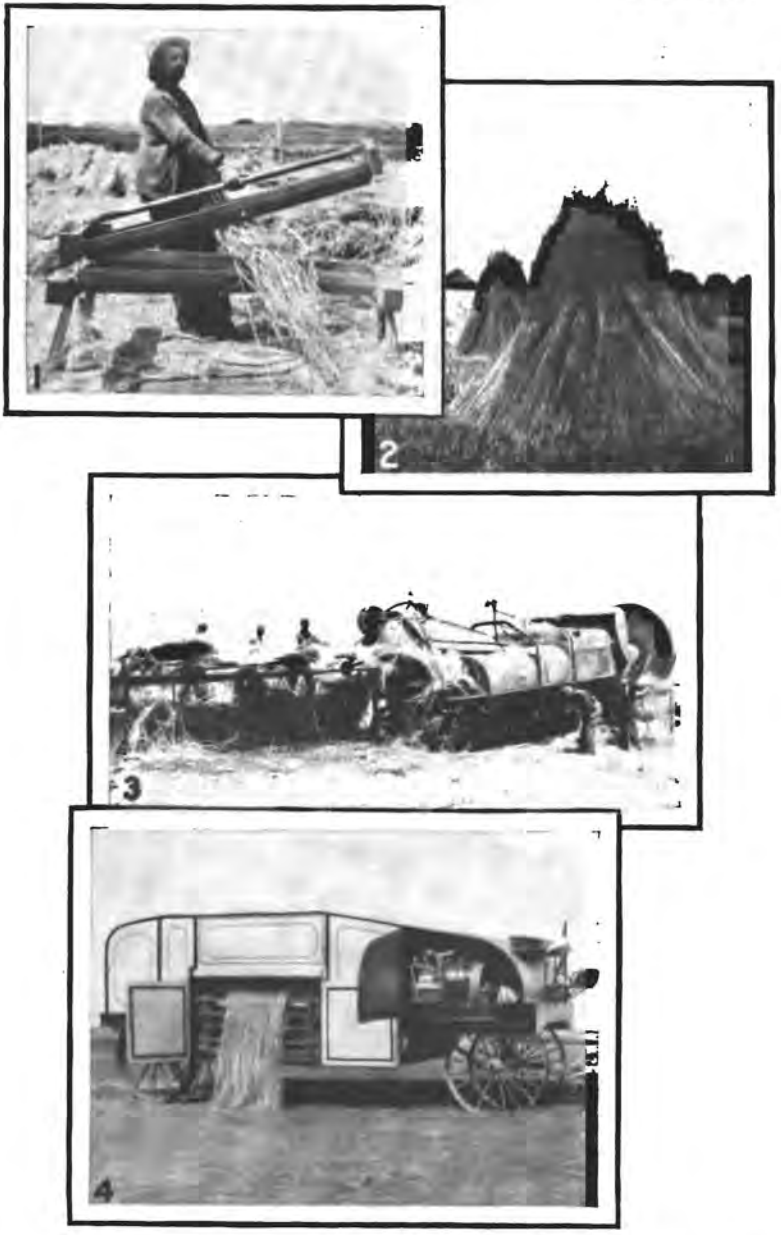


COLLECTING SEED AND RETTING STALKS.

Fig. 1.—Beating off seed from an entire shock of seed hemp. Fig. 2.—Homemade hemp seed-cleaning machine. Fig. 3.—Spreading fiber hemp for retting.

CUTTING HEMP.

Fig. 1.—Cutting hemp by hand, about three-fourths acre per day. Fig. 2.—Self-rake reaper, mostly used; cuts about four acres per day. Fig. 3.—Mowing machine with bar to bend over hemp; cuts about six acres per day.



BREAKING HEMP.

Fig. 1.—The hand brake, cleans about 100 pounds of fiber per day. Fig. 2.—Shock of hemp, tied in bundles for stacking. Fig. 3.—Machine brake which has produced 9,000 pounds of fiber in one day. Fig. 4.—Machine brake which separates and cleans the tow and the line fiber at the same time.

YIELD.

Under favorable conditions the yield of hemp seed ranges from 12 to 25 bushels per acre. From 16 to 18 bushels are regarded as a fair average yield.

COST OF SEED PRODUCTION.

The hemp-seed growers state that it costs about $2.50 per bushel to produce hemp seed, counting the annual rental of the land at about $10 per acre. With the introduction of improved machinery for cleaning the hemp this cost may be somewhat reduced, since it is estimated that with the ordinary methods of rubbing the seed through sieves or beating it to reduce the chaff to finer pieces the cost from beating it off the shock to delivering it at the market is about 50 cents per bushel. These estimates of cost are based on wages at $1.25 per day.

PRICES.

The price of hemp seed, as sold by the farmer during the past 10 years, has ranged from $2.50 to $5 per bushel. The average farm price during this period has been not far from $3 per bushel. Hemp seed is sold by weight, a bushel weighing 44 pounds.

CULTIVATION FOR FIBER.

PREPARATION OF THE LAND.

Fall plowing on most soils is generally regarded as best for hemp, since the action of the frost in winter helps to disintegrate the particles of soil, making it more uniform in character. In practice, hemp land is plowed at any time from October to late seeding time in May, but hemp should never be sown on spring-plowed sod. The land should be plowed 8 or 9 inches in order to give a deep seed bed and opportunity for root development. Plowing either around the field or from the center is recommended, since back furrows and dead furrows will result in uneven moisture conditions and more uneven hemp. Before sowing, the land is harrowed to make a mellow seed bed and uniform level surface. Sometimes this harrowing is omitted, especially when hemp is grown on stubble ground plowed just before seeding. Harrowing or leveling in some manner is recom-

mended at all times, in order to secure conditions for covering the seed at a uniform depth and also to facilitate close cutting at harvest time.

SEEDING.

METHODS OF SEEDING.

Hemp seed should be sown as uniformly as possible all over the ground and covered as nearly as possible at a uniform depth of about three-fourths of an inch, or as deep as 2 inches in light soils. Ordinary grain drills usually plant the seed too deeply and in drills too far apart for the best results. Uniform distribution is sometimes secured by drilling in both directions. This double working, especially with a disk drill, leaves the land in good condition. Ordinary grain drills do not have a feed indicator for hemp seed, but they may be readily calibrated, and this should be done before running the risk of sowing too much or too little. Fill the seed box with hemp seed, spread a canvas under the feeding tubes, set the indicator at a little less than one-half bushel per acre for wheat, and turn the drivewheel as many times as it would turn in sowing one-tenth acre; then weigh the seed that has fallen on the canvas. If the land is to be drilled in both directions, one-half bushel each way, the drill should feed 2.2 pounds for one-tenth acre. One method giving good results is to remove the lower sections of the feeding tubes on grain drills and place a flat board so that the hemp seed falling against it will be more evenly distributed, the seed being covered either by the shoes of the drill or by a light harrow. Good results are obtained with disk drills, roller press drills, and also with the end-gate broadcast seeder. Drills made especially for sowing hemp seed are now on the market, and they are superseding all other methods of sowing hemp seed in Kentucky. Rolling after seeding is advised, in order to pack the soil about the seed and to secure a smooth surface for cutting, but rolling is not recommended for soils where it is known to have an injurious effect.

AMOUNT OF SEED.

Hemp is sown at the rate of about 3 pecks (33 pounds) per acre. On especially rich soil 1½ bushels may be sown with good results, and on poor land that will not support a

dense, heavy crop a smaller amount is recommended. If conditions are favorable and the seed germinates 98 to 100 per cent, 3 pecks are usually sufficient.

When kept dry, hemp seed retains its germinative vitality well for at least three or four years, but different lots have been found to vary from 35 to 100 per cent, and it is always well to test the seed before sowing.

TIME OF SEEDING.

In Kentucky, hemp seed is sown from the last of March to the last of May. The best results are usually obtained from April seeding. Later seedings may be successful when there is a plentiful rainfall in June. In Nebraska, hemp seed was sown in April, May, or sometimes as late as June. In California it is sown in February or March; in Indiana and Wisconsin, in May. In general, the best time for sowing hemp seed is just before the time for sowing oats in any given locality.

After the seed is sown, the hemp crop requires no further care or attention until the time of harvest.

HARVEST.

TIME.

In California, hemp is cut late in July or in August; in Kentucky, Indiana, and Wisconsin it is cut in September. The hemp should be cut when the staminate plants are in full flower and the pollen is flying. If cut earlier, the fiber will be finer and softer but also weaker and less in quantity. If permitted to become overripe, the fiber will be coarse, harsh, and less pliable, and it will be impossible to ret the stalks properly.

METHODS OF HARVESTING.

HARVESTING BY HAND.

In Kentucky, a small portion of the hemp crop is still cut by hand with a reaping knife or hemp hook. (Pl. XLV, fig. 1.) This knife is somewhat similar to a long-handled corn cutter. The man cutting the hemp pulls an armful of stalks toward him with his left arm and cuts them off as near the base as possible by drawing the knife close to the ground; he then lays the stalks on the ground in a smooth, even row,

with the butts toward him, that is, toward the uncut hemp. An experienced hand will cut with a reaping knife about three-fourths of an acre a day. The hemp stalks are allowed to lie on the ground until dry, when they are raked up by hand and set up in shocks until time to spread for retting.

HARVESTING WITH REAPERS.

Sweep-rake reapers are being used in increasing numbers for harvesting hemp in Kentucky and in all other localities where hemp is raised. (Pl. XLV, fig. 2.) While not entirely satisfactory, they are being improved and strengthened so as to be better adapted for heavy work. Three men, one to grind sections, one to drive, and one to attend to the machine, and four strong horses or mules are required in cutting hemp with a reaper. Under favorable conditions, from 5 to 7 acres per day can be cut in this manner. This more rapid work makes it possible to harvest the crop more nearly at the proper time. The stalks, after curing in the gavel, are set up in shocks, usually without binding into bundles unless they are to be stacked.

HARVESTING WITH MOWING MACHINES.

In some places hemp is cut with ordinary mowing machines. (Pl. XLV, fig. 3.) A horizontal bar nearly parallel with the cutting bar, the outer end projecting slightly forward, is attached to an upright fastened to the tongue of the machine. This bar is about 4 feet above the cutting bar and about 20 inches to the front. It bends the hemp stalks over in the direction the machine is going. The stalks are more easily cut when thus bent away from the knives and, furthermore, the bases snap back of the cutting bar and never drop through between the guards to be cut a second time, as they often do when cut standing erect. With a 5½-foot mowing machine thus equipped, one man and one team of two horses will cut 6 to 8 acres per day. The work is regarded as about equal to cutting a heavy crop of clover. The hemp thus cut all falls in the direction the machine is going, the tops overlapping the butts of the stalks. The ordinary track clearer at the end of the bar clears a path, so that the stalks are not materially injured either by the horses or the wheels of the machine at the next round.

The hemp stalks are then left where they fall until retted, or in places where the crop is heavy the stalks are turned once or twice to secure uniform curing and retting. When sufficiently retted the stalks are raked up with a 2-horse hay-rake, going crosswise of the swaths, and then drawn, like hay, to the machine brake. This is the most inexpensive method for handling the crop. It is impossible to make clean, long, straight fiber from stalks handled in this manner, and it is not recommended where better methods are practicable. It is worthy of more extended use, however, for handling short and irregular hemp, and hundreds of acres of hemp now burned in Kentucky because it is too short to be treated in the regular manner might be handled with profit by this method. There may be nearly as much profit in 3½-cent fiber produced at a cost of 2 cents per pound as in 5-cent fiber produced at a cost of 3 cents, provided the land rent is not too large an item of cost.

NEED FOR IMPROVEMENT IN HEMP HARVESTERS.

The most satisfactory hemp-harvesting machines now in use are the self-rake reapers, made especially for this purpose. They are just about as satisfactory for hemp now as the similar machines for wheat and oats were 30 years ago. More efficient harvesting machinery is needed to bring the handling of this crop up to present methods in harvesting corn or small grain. A machine is needed which will cut the stalks close to the ground, deliver them straight and not bruised or broken, with the butts even, and bound in bundles about 8 inches in diameter. A modified form of the upright corn binder, arranged to cut a swath about 4 feet wide, is suggested. Modified forms of grain binders have been tried, but with rather unsatisfactory results. Green hemp 8 to 14 feet high can not be handled successfully by grain binders; furthermore, the reel breaks or damages a large proportion of the hemp. The tough, fibrous stalks, some of which may be an inch in diameter, are more difficult to cut than grain and therefore require sharp knives with a high motion.

A hemp-reaping machine is also needed that will cut the hemp and lay it down in an even swath, as grain is laid with a cradle. The butts should all be in one direction, and the swath should be far enough from the cut hemp so as not to

be in the way at the next round. A machine of this type may be used where it is desired to ret the hemp in the fall immediately after cutting. It might be used for late crops in Kentucky, or generally for hemp farther north, where there is little danger of "sunburn" after the hemp is harvested.

STACKING.

Hemp stalks which are to be stacked are bound in bundles about 10 inches in diameter, with small hemp plants for bands, before being placed in shocks. (Pl. XLVI, fig. 2.) They are allowed to stand in the shock from 10 to 15 days, or a sufficient length of time to avoid danger of heating in the stack. The bundles are hauled from the shocks to the stacks in rather small loads of half a ton or less on a low rack or sled. Three men with a team and low wagon to haul the stalks can put up two hemp stacks of about 8 tons each in a day.

A hemp stack must be built to shed water. It is started much like a grain stack with a shock, around which the bundles are placed in tiers, with the butts sloping downward and outward. The stack is kept higher in the center and each succeeding outer tier projects slightly to a height of 5 or 6 feet, when another shock is built in the center, around which the bundles are carefully placed to shed water and the peak capped with an upright bundle. A well-built stack may be kept four or five years without injury.

Hemp which has been stacked rets more quickly and more evenly, the fiber is usually of better quality, and the yield of fiber is usually greater than from hemp retted directly from the shock. Hemp is stacked before retting, but not after retting in Kentucky. Stacking retted hemp stalks for storage before breaking is not recommended in climates where there is danger of gathering moisture. Retted stalks may be stored in sheds where they will be kept dry.

CARE IN HANDLING.

Hemp stalks must be kept straight, unbroken, and with the butts even. They must be handled with greater care than is commonly exercised in handling grain crops. When a bunch of loose stalks is picked up at any stage of the operation, it is chucked down on the butts to make them even. The loose stalks, or bundles, are handled by hand and not

with pitchforks. The only tool used in handling the stalks is a hook or rake, in gathering them up from the swath.

RETTING.

Retting is a process in which the gums surrounding the fibers and binding them together are partly dissolved and removed. It permits the fiber to be separated from the woody inner portion of the stalk and from the thin outer bark, and it also removes soluble materials which would cause rapid decomposition if left with the fiber. Two methods of retting are practiced commercially, viz, dew retting and water retting.

DEW RETTING.

In this country dew retting is practiced almost exclusively. The hemp is spread on the ground in thin, even rows, so that it will all be uniformly exposed to the weather. In spreading hemp the workman takes an armful of stalks and, walking backward, slides them sidewise from his knee, so that the butts are all even in one direction and the layer is not more than three stalks in thickness. (Pl. XLIV, fig. 3.) This work is usually paid for at the rate of $1 per acre, and experienced hands will average more than 1 acre per day. The hemp is left on the ground from four weeks to four months. Warm, moist weather promotes the retting process, and cold or dry weather retards it. Hemp rets rapidly if spread during early fall, provided there are rains, but it is likely to be less uniform than if retted during the colder months. It should not be spread early enough to be exposed to the sun in hot, dry weather. Alternate freezing and thawing or light snows melting on the hemp give most desirable results in retting. Slender stalks one-fourth inch in diameter or less ret more slowly than coarse stalks, and such stalks are usually not overretted if left on the ground all winter. Hemp rets well in young wheat or rye, which hold the moisture about the stalks. In Kentucky most of the hemp is spread during December. A protracted January thaw with comparatively warm rainy weather occasionally results in overretting. While this does not destroy the crop, it weakens the fiber and causes much loss. When retted sufficiently, so that the fiber can be easily separated from the hurds, or woody portion, the stalks are raked up and set up in shocks, care being exercised to keep them straight and with the

butts even. They are not bound in bundles, but a band is sometimes put around the shock near the top. The work of taking up the stalks after retting is usually done by piecework at the rate of $1 per acre.

WATER RETTING.

Water retting is practiced in Italy, France, Belgium, Germany, Japan, and China, and in some localities in Russia. It consists in immersing the hemp stalks in water in streams, ponds, or artificial tanks. In Italy, where the whitest and softest hemp fiber is produced, the stalks are placed in tanks of soft water for a few days, then taken out and dried, and returned to the tanks for a second retting. Usually the stalks remain in the water first about eight days and the second time a little longer.

In either dew retting or water retting the process is complete when the bark, including the fiber, readily separates from the stalks. The solution of the gums is accomplished chiefly by certain bacteria. If the retting process is allowed to go too far, other bacteria attack the fiber. The development of these different bacteria depends to a large extent upon the temperature. Processes have been devised for placing pure cultures of specific bacteria in the retting tanks and then keeping the temperature and air supply at the best for their development.[1] These methods, which seem to give promise of success, have not been adopted in commercial work.

CHEMICAL RETTING.

Many processes for retting or for combined retting and bleaching with chemicals have been devised, but none of them have given sufficiently good results to warrant their introduction on a commercial scale. In most of the chemical retting processes it has been found difficult to secure a soft, lustrous fiber, like that produced by dew or water retting, or completely to remove the chemicals so that the fiber will not continue to deteriorate owing to their injurious action.

One of the most serious difficulties in hemp cultivation at the present time is the lack of a satisfactory method of retting that may be relied upon to give uniform results without injury to the fiber. An excellent crop of hemp stalks, capa-

[1] Rossi, Giacomo. Macerazione della Canapa. Annali della Regia Scuola Superiore di Agricultura di Portici, s. 2, v. 7, p. 1-148, 1907.

ble of yielding more than $50 worth of fiber per acre, may be practically ruined by unsuitable weather conditions while retting. Water retting, although less dependent on weather conditions than dew retting, has not thus far given profitable results in this country. The nearest approach to commercial success with water retting in recent years in America was attained in 1906 at Northfield, Minn., where, after several years of experimental work, good fiber, similar to Italian hemp in quality, was produced from hemp retted in water in large cement tanks. The water was kept in circulation and at the desired temperature by a modification of the Deswarte-Loppens system.

STEAMING.

In Japan, where some of the best hemp fiber is produced, three methods of retting are employed—dew retting, water retting, and steaming, the last giving the best results. Bundles of hemp stalks are first immersed in water one or two days to become thoroughly wet. They are then secured vertically in a long conical box open at the bottom and top. The box thus filled with wet stalks is raised by means of a derrick and swung over a pile of heated stones on which water is dashed to produce steam. Steaming about three hours is sufficient. The fiber is then stripped off by hand and scraped, to remove the outer bark. The fiber thus prepared is very strong, but less flexible than that prepared by dew retting or water retting.

BREAKING.

Breaking is a process by means of which the inner, woody shell is broken in pieces and removed, leaving the clean, long, straight fiber. Strictly speaking, the breaking process merely breaks in pieces the woody portions, while their removal is a second operation properly called *scutching*. In Italy and in some other parts of Europe the stalks are broken by one machine, or device, and afterwards scutched by another. In this country the two are usually combined in one operation.

HAND BRAKES.

Hand brakes (Pl. XLVI, fig. 1), with little change or modification, have been in use for many generations, and even yet more than three-fourths of the hemp fiber produced in

Kentucky is broken out on the hand brake. This simple device consists of three boards about 5 feet long set edgewise, wider apart at one end than the other and with the upper edges somewhat sharpened. Above this a framework, with two boards sharpened on the lower edges, is hinged near the wide end of the lower frame, so that when worked up and down by means of the handle along the back these upper boards pass midway in the spaces between the lower ones. A carpenter or wagon maker can easily make one of these hand brakes, and they are sold in Kentucky for about $5.

The operator takes an armful of hemp under his left arm, places the butts across the wide end of the brake near the hinged upper part, which is raised with his right hand, and crunches the upper part down, breaking the stalks. This operation is repeated several times, moving the stalks along toward the narrow end so as to break the shorter pieces, and when the hemp appears pretty well broken the operator takes the armful in both hands and whips it across the brake to remove the loosened hurds. He then reverses the bundle and breaks the tops and cleans the fiber in the same manner.

The usual charge for breaking hemp on the hand brake in this manner is 1 cent to 1½ cents per pound. There are records of 400 pounds being broken by one man in a day, but the average day's work, counting six days in a week, is rarely more than 75 pounds. In a good crop, therefore, it would require 10 to 15 days for one man to break an acre of hemp. The work requires skill, strength, and endurance, and for many years there has been increasing difficulty in securing laborers for it. It is plainly evident that the hemp industry can not increase in this country unless some method is used for preparing the fiber requiring less hand labor than the hand brake.

MACHINE BRAKES.

Several years ago a brake was built at Rantoul, Ill., for breaking and cleaning the fiber rapidly, but producing tow or tangled fiber instead of clean, straight, line fiber, such as is obtained by the hand brake. This machine consisted essentially of a series of fluted rollers followed by a series of beating wheels. Machines designed after this type, but improved in many respects, have been in use several years at Havelock, Nebr., and first at Gridley, then at Courtland and Rio Vista,

Cal. These machines have sufficient capacity and are operated at comparatively small cost, the hurds furnishing more than sufficient fuel for the steam power required, but the condition of the fiber produced is not satisfactory for high-class twines and it commands a lower price than clean, long, straight fiber.

The Sanford-Mallory flax brake, consisting essentially of five fluted rollers with an interrupted motion, producing a rubbing effect, has been used to a limited extent for breaking hemp. This machine, as ordinarily made for breaking flax, is too light and its capacity is insufficient for the work of breaking hemp.

A portable machine brake (Pl. XLVI, fig. 4) has been used successfully in Kentucky during the past two years. It has a series of crushing and breaking rollers, beating and scutching devices, and a novel application of suction to aid in separating hurds and tow. The stalks are fed endwise. The long fiber, scutched and clean, leaves the machine at one point, the tow, nearly clean, at another, and the hurds, entirely free from fiber, at another. It has a capacity of about 1 ton of clean fiber per day.

Another portable machine brake has been in use in California during the past two years, chiefly breaking hemp that has been thoroughly air dried but not retted. This hemp, grown with irrigation, becomes dry enough in that arid climate to break well, but this method is not practicable in humid climates without artificial drying. The stalks, fed endwise, pass first through a series of fluted or grooved rollers and then through a pair of beating wheels, removing most of the hurds, and the fiber, passing between three pairs of moving scutching aprons, each pair followed by rollers, finally leaves the machine in a kind of continuous lap folded back and forth in the baling box.

A larger machine (Pl. XLVI, fig. 3), having the greatest capacity and turning out the cleanest and most uniform fiber of any of the brakes thus far brought out, has been used to a limited extent during the past eight years in Kentucky, California, Indiana, and Wisconsin. This machine weighs about 7 tons, but it is mounted on wheels and is drawn about by a traction farm engine, which also furnishes power for operating it. The stalks are fed sidewise in a continuous layer 1 to 3 inches thick, and carried along so that the ends,

forced through slits, are broken and scutched simultaneously by converging revolving cylinders about 12 and 16 feet long. One cylinder, extending beyond the end of the other, cleans the middle portion of the stalks, the grasping mechanism carrying them forward being shifted to the fiber cleaned by the shorter cylinder. The cylinders break the stalks and scutch the fiber on the under side of the layer as it is carried along, and the loosened hurds on the upper side are scutched by two large beating wheels just as it leaves the machine. The fiber leaves the machine sidewise, thoroughly cleaned and ready to be twisted into heads and packed in bales. This machine with a full crew of 15 men, including men to haul stalks from the field and others to tie up the fiber for baling, has a capacity of 1,000 pounds of clean, straight fiber of good hemp per hour. The tow is thrown out with the hurds, and until recent improvements it has produced too large a percentage of tow. It does good work with hemp retted somewhat less than is necessary for the hand brake, and it turns out more uniform and cleaner fiber. For good work it requires, as do all the machines and also the hand brakes, that the hemp stalks be dry. If the atmosphere is dry at the time of breaking, the hemp may be broken directly from the shocks in the field, but in regions with a moist atmosphere, or with much rainy weather, it would be best to store the stalks in sheds or under cover, and with a stationary plant it might be economical to dry them artificially, using the hurds for fuel. Extreme care must be exercised in artificial drying, however, to avoid injury to the fiber.

IMPROVEMENT NEEDED IN HEMP-BREAKING MACHINES.

While hemp-breaking machines have now reached a degree of perfection at which they are successfully replacing the hand brakes, as the thrashing machines half a century ago began replacing the flail, there is still room for improvement. This needed improvement may be expected as soon as hemp is grown more extensively, so as to make a sufficient demand for machinery to induce manufacturers to invest capital in this line. For small and scattered crops a comparatively light, portable machine is desirable, requiring not more than 10 horsepower and not more than four or five laborers of

average skill for its operation. It should prepare the fiber clean and straight, ready to be tied in hanks for baling, and should have a capacity of at least 1,000 pounds of clean fiber per day. For localities where hemp is grown more abundantly, so as to furnish a large supply of stalks within short hauling distance, a larger machine operated in a stationary central plant by a crew of men trained to their respective duties, like workers in a textile mill, will doubtless be found more economical. Artificial retting and drying may also be used to good advantage in a central plant.

The hemp growers of Europe have adopted machine brakes more readily than the farmers in this country, and the hemp industry in Europe is most flourishing and most profitable where the machines are used. Most of the hemp in northern Italy is broken and scutched by portable machines. Machines are also used in Hungary, and the machine-scutched hemp of Hungary is regularly quoted at $10 to $15 per ton higher than that prepared by hand. These European machines may not be adapted to American conditions, but, together with American machines which are doing successful work, they sufficiently contradict the frequent assertion of hemp growers and dealers that "no machine can ever equal the hand brake."

SORTING.

On many hemp plantations the stalks are roughly sorted before breaking, so that the longer or better fiber will be kept separate. The work of sorting can usually be done best at this point, short stalks from one portion of a field being kept separate from the longer stalks of another portion and overretted stalks from stalks with stronger fiber. Sometimes the men breaking the hemp sort the fiber as it is broken. An expert handler of fiber will readily sort it into two or three grades by feeling of it as it leaves the hand brake or the breaking machine. It is a mistaken policy to suppose that the average price will be higher if poor fiber is mixed with good. It may be safely assumed that the purchaser fixing the price will pay for a mixed lot a rate more nearly the value of the lowest in the mixture, and he can not justly do otherwise, for the fiber must be sorted later if it is to be used to the best advantage in the course of manufacture.

PACKING FIBER FOR LOCAL MARKET.

The long, straight fiber is put up in bundles, or heads, 4 to 6 inches in diameter and weighing 2 to 4 pounds. (Pl. XL, fig. 4.) The bundle of fiber is twisted and bent over, forming a head about one-third below the top end. It is fastened in this form by a few strands of the fiber itself, wound tightly around the neck and tucked in so that it may be readily unfastened without cutting or becoming tangled. Three ropes, each about 15 feet long, twisted by hand from the hemp tow, are stretched on the ground about 15 inches apart. The hanks of fiber are piled crosswise on these ropes with the heads of the successive tiers alternating with the loose ends, which are tucked in so as not to become tangled. When the bundle thus built up is about 30 inches in diameter, the ropes are drawn up tightly by two men and tied. These bundles weigh about 200 pounds each. Most of the hemp leaves the farm in this form. Hemp tow, produced from broken or tangled stalks and fiber beaten out in cleaning the long straight hemp, is packed into handmade bales in the same manner.

HACKLING.

In Kentucky, most of the hemp is sold by the farmers to the local dealers or hemp merchants. The hemp dealers have large warehouses where the fiber is stored, sorted, hackled, and baled. The work of hackling is rarely done on the farms. The rough hemp is first sorted by an expert, who determines which is best suited for the different grades to be produced. A quantity of this rough fiber, usually 112 or 224 pounds, is weighed out to a workman, who hackles it by hand, one head at a time. The head is first unfastened and the fiber shaken out to its full length. It is then combed out by drawing it across a coarse hackle, beginning near the top end and working successively toward the center. When combed a little beyond the center, the bundle of fiber is reversed and the butt end hackled in the same manner. The coarse hackle first used consists of three or four rows of upright steel pins about 7 inches long, one-fourth of an inch thick, and 1 inch apart. The long fiber combed out straight on this hackle is called "single-dressed hemp." This may afterwards be treated in much the same manner on a smaller

hackle with finer and sharper needles set closer together, splitting and subdividing the fibers as well as combing them out more smoothly. The fiber thus prepared is called "double-dressed hemp," and it commands the highest price of any hemp fiber on the American market.

The work of hackling is paid for at a certain rate per pound for the amount of dressed fiber produced. The workman therefore tries to hackle and dress the fiber in such a manner as to produce the greatest possible amount of dressed fiber and least amount of tow and waste. The dressed fiber is carefully inspected before payment is made, and there are few complaints from manufacturers that American dressed hemp is not up to the standard.

A large proportion of the hemp purchased by the local dealers is sold directly to the twine and cordage mills without hackling or other handling except carefully sorting and packing into bales.

BALING.

The bales packed for shipment are usually about 4 by 3 by 2 feet. The following table gives the approximate weights per bale:

Average weight per bale of hemp for shipment to mills.

Class of hemp.	Pounds.
Tow	450
Rough	500
Single dressed	800
Double dressed	900

When cleaned by machine brakes the fiber is often baled directly without packing it in the preliminary handmade bales. In this way it has sometimes escaped the process of careful sorting and has brought unjust criticism on the machines. This cause for criticism may easily be avoided by exercising a little more care in sorting the stalks, and, if necessary, the cleaned fiber.

YIELD.

The yield of hemp fiber ranges from 400 to 2,500 pounds per acre. The average yield under good conditions is about 1,000 pounds per acre, of which about three-fourths are line

fiber and one-fourth is tow. The yield per acre at different stages of preparation may be stated as follows:

Stalks:	Pounds.
Green, freshly cut	15,000
Dry, as cured in shock	10,000
Dry, after dew retting	6,000
Long fiber, rough hemp	750
Tow	250

If the 750 pounds of long fiber is hackled it will yield about 340 pounds of single-dressed hemp, 180 pounds shorts, 140 pounds fine tow, and 90 pounds hurds and waste.

The average yields in the principal hemp-producing countries of Europe, based on statements of annual average yields for 5 to 10 years, are as follows:

	Pounds.
Russia	358
Hungary	504
Italy	622
France	662

The yield is generally higher in both Europe and the United States in regions where machine brakes are used, but this is due, in part at least, to the better crops, for machine brakes usually accompany better farming.

COST OF HEMP-FIBER PRODUCTION.

The operations for raising a crop of hemp are essentially the same as those for raising a crop of wheat or oats up to the time of harvest, and the implements or tools required are merely a plow, disk, drill or seeder, a harrow, and a roller, such as may be found on any well-equipped farm. Estimates of the cost of these operations may therefore be based upon the cost of similar work for other crops with which all farmers are familiar. But the operations of harvesting, retting, breaking, and baling are very different from those for other farm crops in this country. The actual cost will, of course, vary with the varying conditions on different farms.

Hemp can not be economically grown in areas of less than 50 acres in any one locality so as to warrant the use of machinery for harvesting and breaking. The following general estimate is therefore given for what may be considered the smallest practical area:

Estimated cost and returns for 50 acres of hemp.

Cost:	
Plowing (in fall) 50 acres, $2 per acre	$100
Disking (in spring), 50 cents per acre	25
Harrowing, 30 cents per acre	15
Seed, 40 bushels, delivered, $4.50 per bushel	180
Seeding, 40 cents per acre	20
Rolling, 30 cents per acre	15
Self-rake reaper for harvesting	75
Cutting with reaper, $1 per acre	50
Picking up from gavels and shocking, $1 per acre	50
Spreading for retting, $1.50 per acre	75
Picking up from retting swath and setting in shocks, $1.40 per acre	70
Breaking 50,000 pounds fiber, including use of machine brake, 1½ cents per pound	750
Baling 125 bales (400 pounds each), including use of baling press, $1.40 per bale	175
Marketing and miscellaneous expenses	150
Total cost	1,750
Returns:	
Long fiber, 37,500 pounds, 6 cents per pound	2,250
Tow, 12,500 pounds, 4 cents per pound	500
Total returns	2,750

It is not expected that a net profit of $20 per acre, as indicated in the foregoing estimate, may be realized in all cases, but the figures given are regarded as conservative where all conditions are favorable.

MARKET.

All of the hemp produced in this country is used in American spinning mills, and it is not sufficient to supply one-half of the demand. The importations have been increasing slightly during the past 20 years, while there has been a decided increase in values. The average declared value of imported hemp, including all grades, for the 4,817 tons imported in 1893, was $142.31 per ton, while in the fiscal year 1913 the importations amounted to 7,663 tons with an average declared value of $193.67 per ton. There have been some fluctuations in quotations, but the general tendency of prices of both imported and American hemp has been upward (Fig. 19.) The quotations for Kentucky rough prime, since October, 1912, have been the highest recorded for this standard grade. Furthermore, the increasing

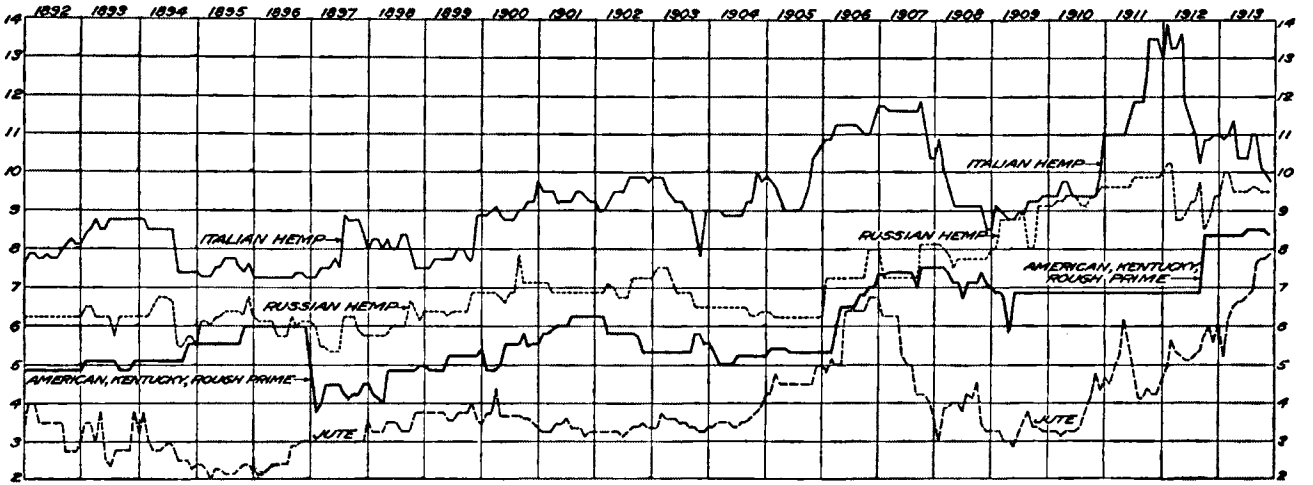


FIG. 19.—Variation in market quotations of American, Russian, and Italian hemp, and also of a standard high grade of jute.

demand for this fiber, together with the scarcity of competing fibers in the world's markets, indicates a continuation of prices at high levels.

EFFECT OF TARIFF.

So far as can be determined from records of importations and prices since 1880, the earliest available statistics, the changes in the rate of import duty on hemp have had no appreciable effect on the quantity imported, on the declared import value [1] of the fiber, or on the quantity produced or the price of American hemp in this country. (Fig. 20.) The tariff acts of 1870, 1883, and 1890, in force until 1894, imposed a duty of $25 per ton on line hemp. From 1894 to 1899 hemp was on the free list, and from 1899 to 1913 it was dutiable at $22.50 per ton.

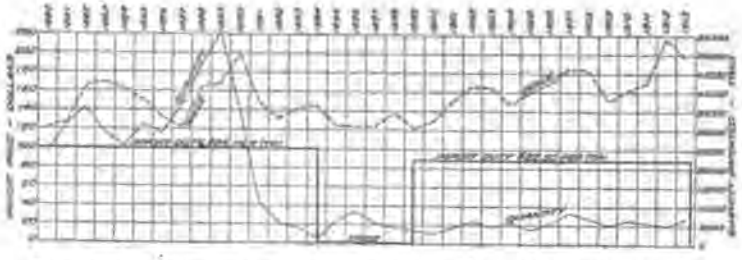


FIG. 20.—Importations and average import price of hemp for 33 years, together with changes in the rate of import duty.

The importations reached a high level in 1899, when hemp was extensively used for binder twine. From that year onward henequen from Yucatan and abacá from the Philippines replaced hemp in binder twine, while jute from India replaced it completely for cotton-bale covering. The increasing demand for hemp for commercial twines has resulted in higher prices for both imported and American hemps, but this demand has been met in this country neither by importation nor by production. There are no accurate statistics of acreage or production in the United States, but there has been a general decline from about 7,000 tons in 1880 to about 5,000 in 1913. The average annual production during the period of free importations, 1894 to 1899, was about 5,000 tons, but slightly less than that of the previous 10

[1] Declared value at port of shipment.

years and about the same as the average of the period of dutiable hemp since then.

The present tariff, 1913, with hemp on the free list, has not been in force long enough to indicate any appreciable effect.

LOCATION OF AMERICAN MILLS.

Some hemp from the larger farms is sold directly to the spinning mills, but most of that produced in this country passes through the hands of local dealers in Kentucky. The hemp imported is purchased either directly from foreign dealers by the mills or through fiber brokers in New York and Boston.

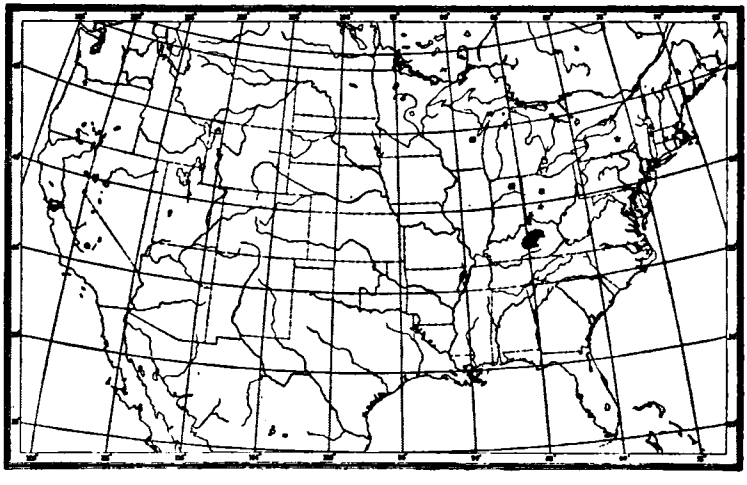


FIG. 21.—Map showing areas (shaded) of hemp cultivation and location (*) of hemp spinning mills in the United States.

There is one twine mill at Frankfort, Ky., on the western edge of the hemp-producing region, and one at Covington, Ky., opposite Cincinnati, but aside from the comparatively small quantities used by these mills and a little used in the mill at Oakland, Cal., practically all the hemp fiber is shipped away from the States where it is produced. There are 28 mills in this country using American hemp, most of them in the vicinity of Boston or New York, as indicated on the accompanying map[1] (fig. 21). In most of these mills other soft fibers, such as jute, China jute, and flax, are also used,

[1] Some of the mills are so close together around New York and Boston that it is impossible to indicate each one by a separate star.

and many of them are also engaged in the manufacture of twines and cordage from the hard fibers—sisal, henequen, abacá (manila), phormium, and Mauritius.

USES.

Hemp is used in the manufacture of tying twine, carpet warp, seine twine, sails, standing rigging, and heaving lines for ships, and for packing. It has been used to some extent for binder twine, but at the relative prices usually prevailing it can not well compete with sisal and abacá for this purpose. Binder twine made of American hemp and India jute mixed has been placed upon the market. This twine is said to give excellent results because it is more smooth and uniform than twine made of hard fiber. The hemp fiber is tougher and more pliable than hard fibers, and the twine is therefore more difficult to cut in the knotter. Hemp is also used to a limited extent for bagging and cotton baling. Only the tow and cheaper grades of the fiber can compete with other fibers for these purposes. The softer grades of hemp tow are extensively used for oakum and packing in pumps, engines, and similar machinery. It endures heat, moisture, and friction with less injury than other fibers, except flax, used for these purposes. Hemp is especially adapted by its strength and durability for the manufacture of carpet warp, hall rugs, aisle runners, tarpaulins, sails, upholstery webbing, belt webbing, and for all purposes in textile articles where strength, durability, and flexibility are desired. Hemp will make fabrics stronger and more durable than cotton or woolen fabrics of the same weight, but owing to its coarser texture it is not well suited for clothing and for many articles commonly made of cotton and wool.

COMPETING FIBERS.

The principal fibers now competing with American-grown hemp are Russian and Hungarian hemp, cotton, and jute. Italian hemp, being water retted, is not only higher in price but it is different in character from the American dew-retted hemp, and it is used for certain kinds of twines and the finer grades of carpet warp for which American hemp is not well suited. Twine made of Italian hemp may, of course, be used sometimes where American hemp twine might serve just as well, but owing to its higher price it is not likely to be used

as a substitute, and it can not compete to the disadvantage of American hemp.

Russian and Hungarian hemp, chiefly dew retted, is of the same character as American hemp and is used for the same purposes. Russian hemp is delivered at the mills in this country at prices but little above those of rough hemp from Kentucky. Most of the Russian and Hungarian hemp imported is of the better grades, the poorer grades being retained in Europe, where many articles are made of low-grade hemp that would be made of low-grade cotton in this country.

In some years, owing to unsuitable weather conditions for retting Kentucky hemp or to greater care in handling Russian hemp and to care in grading the hemp for export from Russia, much of the Russian hemp of the better grades has been stronger and more satisfactory to twine manufacturers than American hemp placed on the market at approximately the same price. It is used for mixing with overretted and weak American hemp to give the requisite strength to twine.

Cotton is now used more extensively than all other vegetable fibers combined. The world's supply of cotton is estimated in round numbers at 5,500,000 tons, valued at nearly $1,000,000,000. The total supply of all other fibers of commerce—hemp, flax, jute, China jute, ramie, sisal, abacá, phormium, Mauritius fiber, cabuya, mescal fiber, and Philippine maguey—amounts annually to about 3,300,000 tons, valued at about $350,000,000. Cotton, therefore, so greatly overshadows all other textile fibers that it may scarcely be regarded as competing directly with any one of them. Cotton is prepared and spun on different kinds of machines from those used for preparing and spinning long fibers. Cotton is not mixed with hemp and is rarely spun in the same mills where hemp is used. Cotton twines do, however, compete with hemp tying twines, and cotton is largely used for carpet warp, where hemp, with its superior strength and durability, would give better service. Less than a century ago hemp and flax were used more extensively than cotton, but the introduction of the cotton gin, followed by the rapid development of machinery all along the line for preparing and spinning cotton fiber, while there has been no corresponding development in machinery for preparing and spinning hemp or other long fibers, has given cotton the supremacy among vegetable fibers. There is little probability that hemp will regain

the supremacy over cotton, even with improved machinery for handling the crop and spinning the fiber, because cotton is better adapted to a wide range of textile products. Hemp should, however, regain many of the lines where it will give better service than cotton.

Jute is the most dangerous competitor of hemp. Jute is produced in India from the bast or inner bark of two closely related species of plants, jute (*Corchorus capsularis*) and nalta jute (*Corchorus olitorius*). These plants are somewhat similar in appearance to hemp, though not at all related to it. They are grown on the alluvial soils in the province of Bengal, India, and to a much less extent in other parts of India, southern China, and Taiwan (Formosa). More than 3,000,000 acres are devoted to this crop, and the annual production is approximately 2,000,000 tons of fiber, valued at $150,000,000. The plants are pulled by hand, water retted in slow streams or stagnant pools, and the fiber cleaned by hand without the aid of even crude appliances as effective as the hand brake for hemp. Jute fiber thus prepared, cleaner, softer, and more easily spun than Kentucky rough-prime hemp, is delivered in New York at an average price of about 4 cents per pound for the better grades. Jute butts, consisting of the coarser fiber cut off at the base, 5 to 10 inches long, are sold in this country at 1 to 2 cents per pound. Most of the long jute fiber comprising the "light jute" grades are of a light straw color, while the "dark jutes," also called "desi jute," are of a dark, brownish gray. The fresh fiber of both kinds when well prepared is lustrous, but with age it changes to a dingy, brownish yellow.

Fresh jute fiber is about two-thirds as strong as hemp fiber of the same weight, but jute lacks durability and rapidly loses its strength even in dry air, while if exposed to moisture it quickly goes to pieces. It is not suitable for any purpose where strength or durability is required.

Jute is used most extensively for burlaps, gunny bags, sugar sacks, grain sacks, wool sacking, and covering for cotton bales. Hemp has been used for all of these purposes, but the cheaper jute fiber now practically holds the entire field in the manufacture of coverings for agricultural products in transit. This is a legitimate field for jute, where it constitutes a "gift package," generally to be used but once, but even in this field hemp may regain some of its uses where it is found that jute does not give sufficient strength or durability.

Jute is often used as an adulterant or as a substitute for hemp in the manufacture of twines, webbing, carpet warp, and carpets. The careless use of the name hemp to indicate jute aids in facilitating this substitution. Twine made of pure jute fiber is sold as "hemp twine" in the retail stores in Lexington, Ky., in the heart of the hemp-growing region. Many of the so-called hemp carpets and hemp rugs are made only of jute, and they wear out quickly, whereas a carpet made of hemp should be as durable as one made of wool. Jute is substituted for hemp very largely in the manufacture of warp for carpets and rugs, a purpose for which its lack of strength and durability makes it poorly fitted. It is to the interest of the purchaser of manufactured articles as well as to the producer of hemp and the manufacturer of pure hemp goods that the line between hemp and jute be sharply drawn. Unfortunately, the difference in the appearance of the fibers by which they may be distinguished is not as strongly marked as the differences between their strength and wearing qualities.

TESTS FOR DISTINGUISHING BETWEEN JUTE AND HEMP.

There are no satisfactory tests for these fibers without the aid of a microscope and chemical reagents. A ready, but uncertain, test consists in untwisting the end of twine or yarn. Jute fiber thus unwound is more fuzzy and more brittle than hemp. The two fibers may be distinguished with certainty with a microscope and chemical reagents, as indicated by the differences in the table which follows:

Reactions of hemp and jute.[1]

Test.	Hemp.	Jute.
Schweitzer's	Clean fiber dissolved.	Bluish color, more or less distinct swelling.
Iodin and sulphuric acid	Greenish blue to pure blue.	Yellow to brown.
Anilin sulphate	Faint yellow	Golden yellow to orange.
Warming in weak solution of nitric acid and potassium chromate, then washing and warming in dilute solution of soda ash and washing again; place on microscopic slide, and when dry add drop of glycerol. Use polariscope (dark field).	Uniform blue or yellow.	Prismatic colors.

[1] Matthews, J. Merritt. The Textile Fibers, p. 349, 1908.

At the present high prices of jute (fig. 4), resulting from increasing demands in foreign markets and a partial failure of the crop in India, jute could not compete successfully with hemp were it not that manufacturers are using it in established lines of goods, and, further, that they are uncertain about securing supplies of hemp.

SUMMARY.

Hemp is one of the oldest fiber-producing crops and was formerly the most important.

The cultivation of hemp is declining in the United States because of the (1) increasing difficulty in securing sufficient labor for handling the crop with present methods, (2) lack of labor-saving machinery as compared with machinery for handling other crops, (3) increasing profits in other crops, (4) competition of other fibers, especially jute, and (5) lack of knowledge of the crop outside of a limited area in Kentucky.

Hemp was cultivated for fiber in very early times in China.

The history of the distribution of hemp from Asia to other continents indicates its relationships and the development of the best fiber-producing types.

Hemp is cultivated in warm countries for the production of a narcotic drug, but for fiber only in moderately cool and humid temperate regions.

Very few well-marked varieties of hemp of fiber-producing types have been developed.

The climate and soils over large areas in the valley of the Mississippi and its tributaries and in the Sacramento and San Joaquin Valleys in California are suited for hemp.

Hemp improves the physical condition of the soil, destroys weeds, and when retted on the ground, as is the common practice, does not exhaust fertility.

Hemp is recommended for cultivation in regular crop rotations to take the place of a spring-sown grain crop.

Fertilizers are not generally used in growing hemp, but barnyard manure applied to previous crops is recommended.

Hemp is rarely injured by insects or fungous diseases.

Broom rape, a root parasite, is the most serious pest in hemp.

Practically all of the hemp seed used in the United States is produced in Kentucky.

The best seed is obtained from plants cultivated especially for seed production, but some seed is obtained from broadcast overripe fiber crops.

The land should be well plowed and harrowed, so as to be level and uniform.

The seed should be sown early in spring by any method that will distribute and cover it uniformly.

Some hemp is still cut by hand in Kentucky, but the use of machinery for harvesting the crop is increasing.

Dew retting is regarded as the most practical method in this country.

Hand brakes for preparing the fiber are still used, but they are being replaced by machines.

The price of hemp has been generally increasing during the past 30 years.

About 30 different spinning mills in the United States, beside dealers in oakum supplies, offer a market for raw hemp fiber.

The market would expand if manufacturers could be assured of larger supplies.

India jute, often retailed under the name hemp, is the most dangerous competitor of hemp.