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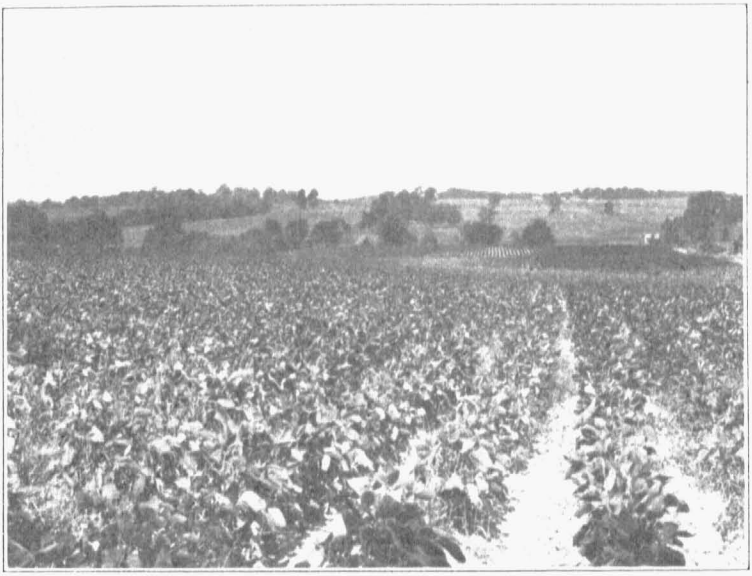
PRODUCTIVE METHODS FOR SOYBEANS IN MISSOURI



Soybeans in mid-season on Missouri upland.

COLUMBIA, MISSOURI
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CONTENTS

In this bulletin will be found practical information on the following topics:

Productive Methods For Soybeans In Missouri

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The purpose of this bulletin is to report to Missouri farmers the facts learned about soybeans from investigations by the Missouri Experiment Station. The practical use of these facts will greatly increase the efficient production of the soybean crop in this State.

IMPORTANCE OF THE CROP

Ten years ago soybeans were unknown in Missouri except in a few localities; but today they are widely grown in Central and North Missouri and are rapidly entering other parts of the State. The greater part of the Missouri soybean crop is grown in combination with corn for hog pasturage. No statistics are available to show the total area of land used in this way, but the practice is widespread not only in Missouri but in the whole Middle West. There is in addition a considerable acreage of soybeans planted annually in Missouri for seed. In 1921 there were approximately 17,000 acres, but some of this crop was cut for hay or used as pasturage and the remainder will fall far short of supplying the demand for seed to plant the total crop of 1922. Indeed the shortage of available seed during the last five or six years has been the main condition limiting the increase of soybean production in this State. The production of soybean seed is therefore highly profitable when the proper methods of growing and handling the crop are well understood.

Ten Reasons Why Soybeans Are Popular in Missouri.—Soybeans have gained popularity in Missouri strictly on their merits. Their good features as observed in our investigations may be briefly summarzed.

1. They make a larger yield of seed than any other legume grown in the State. In our investigations the best varieties have yielded an average of 20 to 25 bushels to the acre, on good land. In favorable seasons the best variety has yielded nearly 35 bushels.

2. In Southwest, Central and North Missouri soybeans will make a larger yield of cured hay than any other annual legume. On any land in the State, not quite fertile enough to grow good crops of alfalfa or red clover, soybeans will produce abundantly the needed crop of legume hay. In Southeast Missouri they will compare very favorably with the cowpea, which has long been considered the best annual plant for hay in that section. Soybean hay is much easier to cure than cowpea hay and probably is more valuable as feed pound for pound because it contains a higher proportion of seed. Indeed it is doubtful that the cured hay of any other legume exceeds in feeding value soybean hay properly cut and cured.

3. Soybeans are unexcelled for planting in combination with corn for hog or lamb pasturage. They make a heavy yield of seed and their erect growth prevents trampling by grazing animals, so that the crop is eaten al-

most completely. In this respect they have a special advantage over other crops planted with corn for the same purpose. Cowpeas, rape, turnips and pumpkins, sometimes used in this way, are considerably damaged by trampling.

4. Soybeans are remarkably drought resistant. In our investigations they have thrived with great vigor through several seasons when corn was a drought-stricken failure. In other seasons they have suffered no noticeable injury from excessive moisture.

5. They can be planted over a wide range of the season from corn planting time until near the first of July, although the most favorable time for planting is near the first of June. Within wide limits of the season soybean planting can wait on the convenience of farm labor.

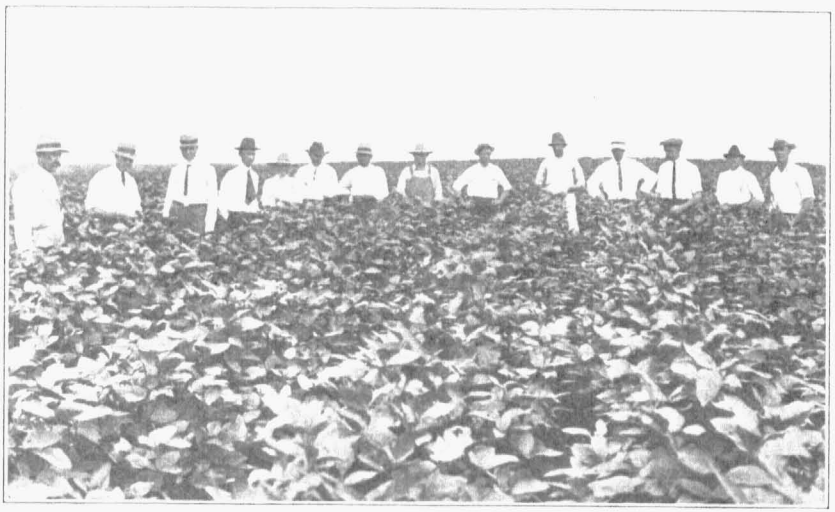

Fig. 2.—A group of De Kalb County farmers studying soybeans under the direction of their county agent.

6. They are nearly an ideal catch crop. By proper management a good yield of soybean hay can be produced on wheat or oats stubble; and in the failure of wheat, oats, corn, or clover, the land can be caught with a full crop of soybeans at any time between early summer and July 1.

7. The soybean crop will fit in any standard rotation of crops in Missouri. A full season growth can be harvested in time to seed wheat on the same land. No further preparation of the land is then necessary for the wheat, if in the beginning the land was properly prepared for soybeans and kept clean during their growing season. A similar practice can be carried out with a soybean catch crop.

8. Soybeans have no special soil requirement. If properly treated they will grow on any type of soil that will produce any standard Missouri crop.

9. They leave the land in fine mechanical condition and they cause little reduction in the supply of nitrogen.

10. They have no important enemies—insect or disease—at the present time in Missouri. The soybean grower may therefore feel safe from damages suffered through other crops.

THE IMPORTANCE OF GOOD METHODS OF PRODUCTION

The soybean crop is well adapted to the climate in any part of Missouri. Also it will grow well on any soil in the State, which will naturally produce any other crop successfully. In fact with the proper management soybeans will grow fairly well on soil that is too thin for the successful production of corn, wheat, oats, barley, alfalfa or clover. Thus the Experiment Station has produced crops of soybeans yielding 10 or 12 bushels of seed or 2 tons of hay to the acre, on some of the thinnest land of the State, with no use of fertilizer or manure. But notwithstanding the easy adaptation of soybeans, they are not easy to produce unless the right methods are

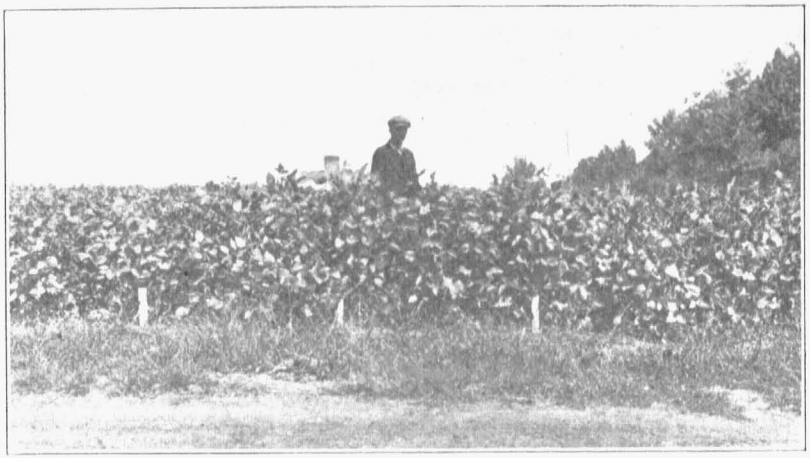

Fig. 3.—Varieties of soybeans at the Missouri Experiment Station, Columbia.

employed. Consequently the average farmer, in his first attempt to grow this crop may find himself in doubt at several stages; and even the more experienced grower usually may improve some of his methods. Therefore this bulletin will not only point out the merits and the usefulness of the soybean crop, but will also discuss, mainly on the basis of experimental evidence, the best methods of producing it in Missouri.

CHOOSING A VARIETY

The varieties of soybeans are very numerous and many of them are widely distributed. They vary not only in their adaptation to climates and soils, but also in their usefulness for different purposes. Thus there are varieties especially suitable for fertile land, others for poor land; some for early planting, others for late planting; some for a seed crop, others for a hay crop; some for planting with corn, others for planting with such crops

as Sudan grass and sorghum. In fact for any condition or purpose a few varieties, or often a single variety, will be found more suitable than any others. Therefore the selection of the right variety for the right place and purpose is highly important. Perhaps no other factor has greater influence upon the success of the crop.

To find out the varieties of soybeans best adapted in Missouri, the Experiment Station began in 1916 an extensive test of all which then seemed promising. There were 52 in the first test and although a few of these were duplicate types under different names, this list included under one name or another most of the varieties which in the whole country are now of recognized importance.

METHODS OF MAKING THE TEST

The Experiment Station field on which the tests were conducted may in general be described as a well drained upland silt loam of about average fertility. Each variety was planted in a block of 4 rows, each row 130 feet long and 32 inches wide. The planting was in 3 series, so that a total of 12 rows (.08 of an acre) was given to each variety. The rate of planting was standardized for each variety and eventually all rows in the test contained the same number of plants, spaced 4 inches apart. The land was prepared about as for corn and the planting date was within a few days of June 1, except in 1916 when it was July 1. The crop was cultivated very clean throughout the growing season. In 1916 and 1917 the varieties were harvested wholly for seed, but in 1918 to 1921 inclusive, they were harvested for both seed and hay. At the hay stage two alternate rows of each 4-row block were harvested for hay and the remaining two rows were later harvested for seed. In 1918 and 1919 the yields of hay from all varieties were recorded on the basis of field cured weights, but in 1920 and 1921 on the basis of a standard content of moisture (12.5 per cent), arrived at from the yields of absolute dry matter.

Undesirable Varieties.—It was realized early in this test that a good variety must have not only the capacity to make a large yield, but also the qualities which make it, as a crop, fit the conditions under which it is to be grown. Thus in Missouri a good variety for the production of seed must mature early enough to be followed by the timely seeding of wheat, must be tall enough for convenient harvesting with a grain binder even though this implement is not always used, must not lodge on upland soil of at least average fertility, and must not shatter more than a small proportion of its seed at maturity. A variety for the production of hay must have the habit of erect growth on soil of average fertility, must produce an abundant foliage and fine stems together with a fair yield of seed, must shed but few leaves before reaching the stage of maturity for hay, and must not develop extreme woodiness of the stem before the hay stage (well-filled pods). Accordingly at the end of a two-year test, the varieties in Table 1 were discarded because of (1) low yields of seed (2) the possession of one or more of the undesirable qualities just indicated or (3) duplication of another variety. It is of course possible that any of the varieties—Cloud, Nuttall, 19981B, Swan, 19981, Peking and Black Eyebrow—which were discarded only on account of low yields in the test at Columbia, might in

another part of the State find an environment in which they would outyield any of the desirable varieties reported in Table 2. But this seems improbable in view of the wide difference between the yields of the two groups at the end of the 2-year period (1916 and 1917). Any of the varieties which were discarded because of undesirable features other than low yield, would doubtless prove generally undesirable anywhere in Missouri, because of its failure to fit the conditions under which it must be grown in this State.

TABLE 1.—DUPLICATES AND UNDESIRABLE VARIETIES ELIMINATED FROM THE TEST AFTER TWO YEARS.

Varieties	Acre yields in bushels of seed			Reasons for elimination
	1916	1917	Av.	
Taha	27.2	21.1	24.1	Late maturity; coarse stems.
Mammoth Yellow	20.6	2.9	11.7	Late maturity; coarse stems.
Jet	26.1	15.8	20.9	Late maturity; coarse stems.
Edward	13.6	2.6	8.1	Late maturity; coarse stems.
Baird	24.5	15.4	19.9	Late maturity; lodging habit.
Chiquita	22.0	13.8	17.9	Late maturity; lodging habit.
Missouri 2	23.1	15.8	19.4	Late maturity; shatters many seed.
Arlington	23.0	16.4	19.7	Late maturity.
Hope	21.8	8.0	14.9	Late maturity.
Tokio	24.3	4.4	14.3	Late maturity.
Buckshot	18.6	16.4	17.5	Dwarfed growth; shatters many seed
Flat King	20.4	12.1	16.2	Dwarfed growth; shatters many seed
Columbia	25.6	15.8	20.7	Woody stems; shatters many seed.
Austin	28.4	16.2	22.3	Woody stems; shatters many seed.
Auburn	23.4	14.8	19.1	Shatters many seed.
Elton	21.1	17.2	19.1	Shatters many seed.
Pingsu	24.9	12.2	18.5	Shatters many seed.
Nemo	24.0	13.0	18.5	Shatters many seed.
Meyer	26.1	10.0	18.0	Shatters many seed.
Kingston	18.6	12.0	15.3	Shatters many seed.
Sherwood	18.6	9.8	14.2	Shatters many seed.
Kentucky	22.2	16.1	19.1	Dwarfed growth.
Brookes	19.9	15.4	17.6	Dwarfed growth.
Ogema	16.4	7.8	12.1	Dwarfed growth.
Butterball	22.0	14 1	18.0	Low growth; scanty foliage.
19981B	23.8	9.9	16.8	Low yield.
Swan	20.9	10.6	15.7	Low yield.
Cloud	17.3	16.1	16.7	Low yield.
Nuttall	22.7	10.1	16.4	Low yield.
Peking	20.1	10.6	15.3	Low yield.
Black Eyebrow	17.2	11.8	14.5	Low yield.
19981	20.2	10.1	15.1	Low yield.
Amherst	18.0	12.0	15.0	Low yield.
Sable	24.3	12.7	18.5	Duplicate of Wilson.
17268C	27.2	17.2	22.2	Duplicate of Haberlandt.
Mongol	24.5	13.5	19.0	Duplicate of Medium Yellow.

Desirable Varieties.—Sixteen varieties whose yields are reported in Table 2, had yielded well during the 2-year period and very few of them had shown in a marked degree any of the undesirable features common among the varieties in Table 1. Accordingly they were tested for an addi-

tional period of 4 years, the test ending in 1921. Their yearly and average yields for the 6-year period may be noted. A few of these varieties while not of the highest rank in yield, have been kept in the test for particular reasons: Ito San, because of its extremely early maturity; Ohio 9035 and Wisconsin Black, because a few years ago these two were highly advertised in this section. The relatively high yield of Ito San in 1916 is noticeable, but probably it was due to the late date of planting (July 1) which did not allow most of the other varieties enough time for their best development.

TABLE 2.—DESIRABLE VARIETIES OF SOYBEANS TESTED FOR A PERIOD OF SIX YEARS. (Acre-yields in bushels of seed and tons of hay.)

Variety	1916	1917	1918		1919		1920		1921		Average	
	bu.	bu	bu.	tons	bu.	tons	bu.	tons	bu.	tons	bu.	tons
Haberlandt	26.1	15.9	19.3	1.8	22.1	2.5	34.2	2.8	34.6	1.9	25.4	2.3
Morse	27.4	13.8	16.4	2.1	22.4	2.2	33.2	3.0	28.2	2.3	23.6	2.4
Okute	26.8	20.6	14.7	1.4	18.9	1.9	32.7	2.2	26.2	2.1	23.3	1.9
Virginia	30.2	16.7	15.5	1.9	18.9	2.6	31.0	2.8	26.4	2.4	23.1	2.4
Mikado	26.1	10.2	17.5	1.9	22.3	2.4	28.9	3.1	32.3	2.3	22.9	2.4
Chesnut	22.7	19.9	16.1	1.7	20.1	2.3	31.5	2.2	24.8	1.8	22.5	2.0
Shingto	20.4	18.3	14.9	2.2	21.8	2.2	30.9	2.4	28.1	2.2	22.4	2.3
Ebony	25.6	16.4	20.2	2.2	19.9	2.9	26.4	2.1	25.3	2.2	22.3	2.4
Ohio 9035	23.0	11.3	16.0	1.7	19.4	2.3	30.9	3.0	32.4	2.3	22.2	2.3
Medium Yellow	23.8	13.3	16.1	1.9	20.6	2.2	26.1	2.4	30.4	2.5	21.7	2.3
Wilson	23.4	16.4	15.3	2.0	17.7	2.2	29.2	2.3	24.4	2.1	21.1	2.4
Manchu	21.6	19.0	13.4	1.3	18.4	1.8	25.8	1.3	24.7	1.9	20.5	1.6
Habero	19.9	17.0	13.9	1.2	19.5	2.3	26.0	1.8	25.3	2.2	20.3	1.9
Ito San	28.4	15.1	13.7	1.3	16.6	2.1	25.2	1.3	20.0	1.9	19.8	1.7
Early Brown	18.8	19.3	13.9	1.3	17.7	2.0	24.0	1.2	22.0	2.0	19.3	1.6
Wisconsin Black	.....	.....	19.0	14.3	2.1	20.4	2.3	22.3	1.4	20.4	2.2	19.3	2.0

TESTS OF DESIRABLE VARIETIES IN REPRESENTATIVE SECTIONS OF THE STATE

It was hardly possible to test in other sections of the State so many varieties as were tested on the Experiment Station field at Columbia. Consequently there were selected from among the varieties found desirable in the Columbia test, a few for each of 5 representative State sections. The selection of a given variety was based on (1) high yields at Columbia and (2) general fitness, as indicated by features shown at Columbia, for the conditions of the section in which it was to be grown. Morse, Mikado, Medium Yellow, Wilson and Virginia, were all high yielders and, in addition, showed in the smallest degree any of the undesirable features by reason of which the varieties in Table 1 were discarded at the end of two years. Consequently they were chosen for the sectional tests and Ito San was added because of its particular value in maturing early. There was a considerable element of judgment in the selection of these varieties from among many other good ones, and necessarily some chance of error, but on the whole it was perhaps the best selection that could have been made.

The Kennett (Dunklin County) Test.—In 1920 and 1921, Wilson, Mik-

ado, Morse and Virginia, were tested on the Lintonia fine sandy loam soil of Dunklin County, in the extreme southeastern part of the State. This type of soil covers a considerable area in the delta section of Southeast Missouri, and although it is less fertile than the heavy loams of the same section, it may still be considered fairly productive. In 1920 and 1921, land adjacent to the test plots of soybeans produced an average of 22.8 bushels of corn, and 1018 pounds of seed cotton.

In this test each variety was planted in a block of 8 rows, each row 500 feet long and 3.2 feet wide. The planting was in 2 series, so that a total of 16 rows (0.58 of an acre) was given to each variety. The land was well prepared and the crop was kept very clean during the growing season. All varieties were harvested wholly for seed, with the results shown in Table 3.

Fig. 4.—Soybeans grow vigorously on the sandy ridge land of Southeast Missouri.

These results indicate the superior capacity of Virginia and Wilson to yield on the sandy ridge land of Southeastern Missouri. The tall, leafy growth of these varieties avoids a loss of seed in harvesting and in addition makes a good yield of hay. On the other hand, Morse and Mikado made in the Kennett test a very short stemmy growth and bore their seed so near the ground that a considerable loss in harvesting with a mower or a binder would have been unavoidable. On the whole it may be concluded that for this type of soil the tall growing varieties Virginia and Wilson, are superior to Morse, Mikado and similar varieties, which make a coarser, shorter growth. Virginia is probably a better variety than Wilson on soil similar to that of this test.

TABLE 3.—ACRE YIELDS IN BUSHELS OF SOYBEAN SEED IN THE KENNETT (DUNKLIN COUNTY) TEST.

Varieties	1920	1921	Averages
Virginia	13.4	19.3	16.4
Wilson	11.6	17.9	14.8
Morse	11.2	12.3	11.8
Mikado	8.8	11.1	10.0

The Cuba (Crawford County) Test.—In 1919, 1920 and 1921, Wilson, Mikado, Morse, Medium Yellow, Virginia and Ito San, were tested on the Lebanon silt loam soil of Crawford County. This type of soil predominates on the ridges of the Ozark section of Missouri. It is low in organic

matter and its natural fertility is somewhat below that of the average soil of the Ozark region. During the three years of the test, land adjacent to the soybeans has yielded an average of 8.2 bushels of corn, 8.6 bushels of wheat, and 27.9 bushels of Kafir to the acre. In these tests each variety was planted in a block of 8 rows, each row 300 feet long and 3.5 feet wide. The land was well prepared and was cultivated very clean during the growing season. The planting was in 2 series, which gave a total of 16 rows (0.39 of an acre) to each variety. One-half the area of each variety in each series was harvested for seed and the other half for hay, the yields of the latter being recorded as cured hay containing 12.5 per cent of moisture. All results of the test are reported in Table 4.

Fig. 5.—A good growth of soybeans on upland soil in Crawford County.

In this test Virginia made a growth tall enough to be harvested by a mower or a binder, but the other varieties, except Wilson, were so short that their harvest by hand was necessary. In addition its yields of seed were superior to those of any other variety. When its suitable growth

Table 4.—Acre Yields in Bushels of Soybean Seed and Tons of Soybean Hay in the Cuba (Crawford County) Test.

Varieties	1919		1920		1921		Averages	
	Seed	Hay	Seed	Hay	Seed	Hay	Seed	Hay
Virginia	2.9	0.3	5.1	0.8	9.9	2.1	6.0	1.1
Medium Yellow	2.7	0.3	4.3	0.6	9.6	1.8	5.5	0.9
Morse	2.3	0.2	3.6	0.9	8.9	2.3	4.9	1.1
Wilson	2.4	0.2	3.9	0.5	8.5	1.6	4.9	0.8
Mikado	2.5	0.2	3.6	0.6	7.8	1.8	4.6	0.9
Ito San	1.8	0.1	3.0	0.4	....	....	2.4	0.3

and superior yields are jointly considered, Virginia stands unquestionably a highly desirable variety for the ridge lands of the Ozark section. In 1921, on another part of the same farm, only slightly more fertile than the land on which the test was conducted, Virginia exceeded in height its growth on the more fertile soils at Columbia, Kirksville, Warrensburg and Maryville, although its yield of seed was not so large as its average yields on these soils.

The increase in the yields of all varieties from the first to the third year of the Cuba test is worthy of note. The only suggested reasons for this fact are (1) the probability of an increasing effectiveness of inoculation and (2) the possibility of an increased adaptation. Soybeans had not prevously been grown in the locality of the test; inoculation was perhaps not wholly successful in the first year; in the second and third year all seed planted in the test had been produced on the same land the year previous. Future yields of soybeans on the Cuba field will be recorded with uncommon interest in this matter.

The Kirksville (Adair County) Test*.—In 1919, 1920 and 1921, Wilson, Mikado, Morse, Medium Yellow, Virginia and Ito San, were tested on the Grundy silt loam soil of Adair County. This dark, fertile soil covers a broad area of the rolling prairies of North Central and Northeast Missouri. In productivity it is considerably above the average of the soils of the State. During the three years of the test, land adjoining the plots of soybeans has yielded an average of 40.5 bushels of corn, 14.2 bushels of wheat, and 28.2 bushels of oats to the acre. In these tests each variety was planted in a block of 3 rows, each row being 224 feet long and 3 feet wide. The planting was in 2 series and a total of 6 rows (0.09 of an acre) was given to each variety. Preparation of the land and cultivation of the crop were thorough and clean. Each variety was harvested for seed, with the results shown in Table 5.

TABLE 5.—ACRE YIELDS IN BUSHELS OF SOYBEAN SEED IN THE KIRKSVILLE (ADAIR COUNTY) TEST.

Varieties	1919	1920	1921	Average
Wilson	11.0	12.4	22.0	15.1
Mikado	13.0	12.6	23.8	16.5
Morse	12.1	15.0	28.6	18.6
Medium Yellow	7.5	14.4	23.2	15.0
Virginia	8.4	10.8	20.3	13.2
Ito San	14.9	14.0	18.4	15.8

In this test Mikado and Morse made the highest average yields of seed, although the data are not sufficient to establish fully their superior yielding capacity. However, the objection found against these varieties in the Kennett and Cuba tests—a growth too short to be harvested with a mower or binder, without a serious loss of seed—was not found in the Kirksville test. On this land, more productive than that at Kennett or Cuba, they made a

*Conducted at Kirksville in cooperation with the Northeast Missouri State Teachers College.

vigorous growth, quite tall enough to be handled with these harvesting implements. Virginia made notably low yields in each year of the test and its average yield was considerably lower than that of any other variety. It seems unsuited to growth conditions represented in the locality of Kirksville. Ito San made comparatively high yields in 1919 and 1920, but it did not at any time show the high yielding capacity of the leading varieties in 1920. On the whole it seems probable that Morse and Mikado are the more desirable varieties for conditions similar to those of this test.

The Warrensburg (Johnson County) Test*.—In 1917, 1919, 1920 and 1921, Morse, Medium Yellow, Wilson, Mikado, Virginia and Ito San, were tested on the Summit silt loam soil of Johnson County. This black limestone land represents an extensive rolling prairie region in the West Central part of the State, mainly south of the Missouri river. Its average productivity is high and the field on which the test was conducted is at least

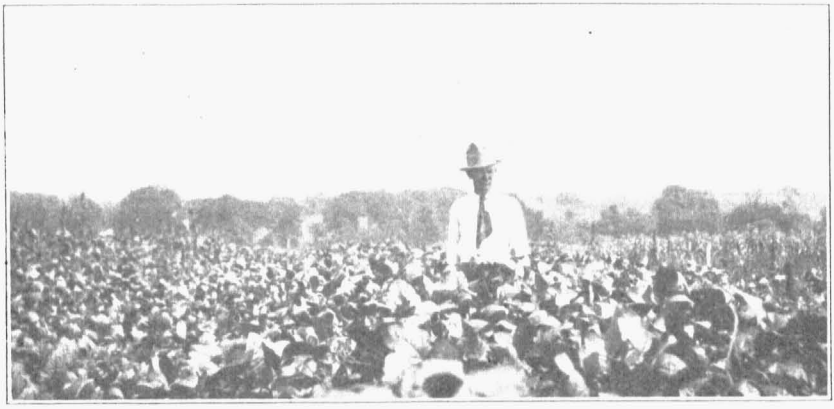

Fig. 6.—A large yield of soybean hay was secured from this Johnson County field.

moderately fertile. During the four years of the test, land adjacent to the soybeans has yielded an average of 38.9 bushels of corn, 17.9 bushels of wheat, and 31.2 bushels of oats to the acre. In these tests each variety was planted in a block of 4 rows, each row 180 feet long and 3.5 feet wide. The planting was in 2 series, and a total of 8 rows (0.11 of an acre) was given to each variety. Preparation of the land and cultivation of the crop during the growing season were thorough and clean. One-half the area of each variety in each series was harvested for seed and the other half for hay, the yields of the latter being recorded as cured hay containing 12.5 percent of moisture. The results of the test are reported in Table 6.

In this test Wilson was consistently a good yielder of seed and its average is considerably higher than that of any other variety. It was also a superior variety for hay, if quality as well as weight be considered. It is leafier and finer stemmed than Morse, Mikado or Medium Yellow, and consequently more desirable for hay, when its yields equal theirs. Morse and

*Conducted at Warrensburg in cooperation with the Central Missouri State Teachers College.

Medium Yellow also yielded well in both seed and hay. Mikado was consistently the lowest yielder of seed, and its yields of hay although fairly high in weight were low in quality. Virginia, as at Kirksville, did not approach the high rank it reached in the Kennett and Cuba tests. It may therefore be concluded that Wilson is a superior variety for conditions similar to those of this test.

TABLE 6.—ACRE YIELDS IN BUSHELS OF SOYBEAN SEED AND TONS OF HAY IN THE WARRENSBURG (JOHNSON COUNTY) TEST.

Varieties	1917		1919		1920		1921		Averages	
	Seed	Hay	Seed	Hay	Seed	Hay	Seed	Hay	Seed	Hay
Wilson	14.7	2.6	19.8	2.4	13.2	1.8	16.1	1.1	16.0	2.0
Mikado	12.9	2.9	10.5	1.3	10.9	2.4	7.9	1.0	10.6	1.9
Morse	15.1	3.3	15.8	1.3	13.4	2.5	10.5	1.1	13.7	2.1
Medium Yellow	....	....	13.0	2.0	13.7	2.6	12.5	1.0	13.1	1.9
Virginia	....	....	15.9	1.8	12.1	2.3	8.3	1.2	12.1	1.8

The Maryville (Nodaway County) Test*.—In 1917 to 1921 inclusive, Morse, Medium Yellow, Wilson, Mikado, Virginia and Ito San, were tested on the Marshall silt loam soil of Nodaway County. This dark, rolling, highly fertile land, covers a wide territory in Northwest Missouri. During the five years of the test, land adjacent to the test plots of soybeans has yielded an average of 41.1 bushels of corn, 30.4 bushels of wheat, and 53.4 bushels of oats to the acre. In this test each variety was planted in a block of 4 rows, each row 354 feet long and 3.5 feet wide. The planting was in 2 series, so that a total of 8 rows (0.23 of an acre) was given to each variety. Preparation of the land and cultivation during the growing season were thorough and clean. The varieties were harvested wholly for seed in 1917 and 1918, but in 1919, 1920, and 1921, one-half the area of each variety in each series was harvested for seed and the other half for hay. The yields of hay are recorded as cured hay containing 12.5 per cent of moisture. The results of the test are reported in Table 7.

TABLE 7.—ACRE YIELDS IN BUSHELS OF SOYBEAN SEED AND TONS OF HAY IN THE MARYVILLE (NODAWAY COUNTY) TEST.

Varieties	1917	1918	1919		1920		1921		Averages	
	Seed	Seed	Seed	Hay	Seed	Hay	Seed	Hay	Seed	Hay
Medium Yellow	18.0	13.4	24.3	1.9	13.4	2.1	22.0	1.9	18.2	2.0
Wilson	18.0	10.6	23.0	2.0	13.8	2.1	20.0	2.0	17.1	2.0
Virginia	14.1	9.5	22.5	2.2	13.4	2.0	17.6	1.8	15.4	2.0
Mikado	18.1	15.1	30.1	1.8	17.2	1.9	24.4	1.9	21.0	1.9
Morse	17.6	11.7	23.2	1.7	14.0	2.1	23.3	2.0	18.0	1.9
Ito San	15.6	8.9	20.6	1.1	12.4	1.3	18.8	1.7	15.3	1.4

*Conducted at Maryville in cooperation with the Northwest Missouri State Teachers College.

Mikado was a consistent leader in yields of seed, followed by Medium Yellow and Morse. Wilson ranks between these varieties and Virginia and Ito San. The last named two were consistently low in yields of seed, and although Virginia made good yields of hay, it was rather low in value because of its small proportion of seed. Wilson made good yields of hay high in quality because of its leafiness, fine stems and fair proportion of seed. It is probably the best variety for hay and for general purposes, under conditions similar to those of this test, while Mikado is strongly indicated as the best variety for seed.

Summary of the Tests of Varieties.—1. Morse, Medium Yellow, Mikado, Wilson and Virginia, were selected for testing in representative sections of Missouri, because of (a) their high yields and (b) their general

Fig. 7.—This fine crop of soybean hay, Wilson variety, was grown in Nodaway County.

fitness for the conditions of the sections in which they were to be grown, both of these qualifications having been shown in the Columbia test.

2. By the results of the Kennett and Cuba tests, Virginia is strongly indicated as the most desirable variety for seed and hay on soils of medium and lower than medium fertility in South Missouri. Wilson also is indicated as a good variety for soils of this type. But there is no evidence to indicate that either of these varieties is superior to Morse, Mikado, or Medium Yellow, on the more fertile soils of this section. On soils moderately fertile, fertile and highly fertile, at Warrensburg, Kirksville and Maryville, respectively, Virginia yielded poorly in comparison with most of the varieties. Its high yields at Columbia (Table 2) may be explained by the fact that here its marked tendency to lodge on fertile soils was offset by careful methods of harvesting, which secured its yields completely.

3. The Warrensburg test indicates Wilson as a superior variety for

seed and hay on Central Missouri soils somewhat above the average in fertility.

4. At Kirksville, Morse and Mikado were the highest yielders and are probably superior varieties for soils in Northeast Missouri approaching a high degree of fertility.

5. At Maryville, on highly fertile soil, Mikado was a consistent leader in yields of seed and seems generally desirable for soils of this type in Northwest Missouri. Morse and Medium Yellow also yielded well. For this soil Wilson is indicated as a good hay and general purpose variety.

6. The relatively high yields of Morse and Mikado at Columbia, Kirksville, and Maryville, together with their relatively low yields at Kennett and Cuba, make strong evidence of the adaptation of these varieties to fertile soil. However, Mikado makes a comparatively low growth, and consequently is not suitable for soils of medium to low fertility, on account of the difficulty of harvesting.

7. Ito San was generally a low yielder under all conditions. It is doubtless unsuited to any part of the State, except when very late planting is necessary. Medium Yellow was not a leader in any of the tests.

8. The high yields at Columbia, higher than those on more fertile soil at Kirksville and Maryville, were doubtless the result of better methods of production, especially harvesting.

9. The high yields of Haberlandt at Columbia, together with its stiff, erect habit of growth, make this a promising variety for the more fertile soils.

HOW TO RECOGNIZE VARIETIES

Descriptions of Varieties.—Different varieties of soybeans are often sold under the same name and different names are often applied to the same variety. Consequently it is useful not only to know the name of a desired kind, but also to recognize the kind itself, otherwise its genuineness is not always assured. For the use of the grower in recognizing one or more of the varieties just recommended, all of them are here described. Descriptions of Mammoth Yellow and Ito San are included, because these very undesirable kinds are often sold under popular names to Missouri farmers. It will be noted that the descriptions are based mainly on characters displayed by the mature plant, for at maturity identification is more certain than at any other stage. Of course this may leave the grower for a whole season with an unknown variety on his hands, but it is better to find out and discard a false variety at the end of the first season than to continue growing it on the assumption that it is a desired kind.

Morse.—White flowers; whitish hairs on mature pods; light green to yellow-green seed, medium large and roughly round; dark seed scar, darker than the seed coat, but not black; erect, medium coarse plant, about 2 feet tall at maturity on average soil. Note probable maturing periods of Morse in Table 8.

Mikado.—Purple flowers; tan-colored hairs on mature pods; green small, round seed; seed scar dark but not black; erect, bunchy, somewhat dwarfed plant, though tall enough to harvest on good land. Note probable maturing period of Mikado in Table 8.

Medium Yellow.—Purple flowers; tan-colored hairs on mature pods; yellow,

glossy seed, medium small and somewhat flattened; seed scar of a color similar to seed coat; erect plant, not quite so coarse as Morse, but sometimes slightly taller. Note probable maturing periods of Medium Yellow in Table 8.

Haberlandt.—White flowers; tan-colored hairs on mature pods; yellow seed, similar in size to Morse, but even less round in outline; seed scar darker than the seed coat, but not black; height of plant and habit of growth very similar to Morse. Note probable maturing periods of Haberlandt in Table 8.

Wilson.—White flowers; whitish hairs on mature pods; black, glossy seed, medium small, flattened and sometimes kidney-shaped; tall, slender, leafy plant, with tendency to vine. Note probable maturing periods of Wilson in Table 8.

Virginia.—Purple flowers; tan-colored hairs on mature pods; tan or brown seed, medium small, flat and kidney-shaped; inconspicious seed scar; tall, slender, leafy plant—taller and somewhat coarser than Wilson—with tendency to vine, especially on rich land. Note probable maturing periods of Virginia in Table 8.

Ito San.—Purple flowers; tan-colored hairs on mature pods; yellow, medium small, fairly round seed, with very distinct dark or black spot near the end of the seed scar which is itself inconspicious; short, stiff, bunchy, coarse, dwarfed plant. Note the probable maturing periods of Ito San in Table 8.

Mammoth Yellow.—White flowers; whitish hairs on mature pods; yellow seed when perfectly matured, greenish-yellow when matured in short season, always large, nearly round, uniform in size and shape, very attractive in bulk lots, a favorite in show exhibits of soybean seed; light brown seed scar; tall, coarse, somewhat slender, strong growing plant; dark green, large, coarse, puckered leaves; maturing periods 120 to 130 days for hay and 140 and 150 days for seed; too late for Missouri, nevertheless its seed is frequently sold into this State.

Maturing Periods of Different Varieties.—The varieties of soybeans previously recommended for several sections of the State, differ considerably in time required for maturing. It is often important that the grower should know approximately the number of days necessary for the growth of his crop from planting to maturity, for with this knowledge he is better able to adjust its production to the length of the season, plan of rotation, and the convenience of his labor. Accordingly this information is given in Table 8, as the result of years of observation at Columbia, and will apply directly to Central Missouri. However, in either South or North Missouri the growth periods of any variety in this Table may be expected to vary not more than a week from the number of days stated.

PREPARATION OF THE LAND

Soybeans make their highest yields on a well prepared seedbed. Disking alone is not enough; the land should be plowed either in the fall or spring, and previous to planting, worked into a fine mellow condition. Soybeans do not grow well on land in the state of preparation usually made for cowpeas, which fact has been the cause of many failures, especially in sections where the cowpea is a familiar crop. Soybeans do not smother weeds so successfully as do cowpeas; for a thrifty growth they require

much better preparation of the seedbed. It is the common experience of soybean growers that to produce satisfactory yields of this crop the land must be prepared fully as well as for corn—and somewhat later, since the best time for planting soybeans is about June 1.

TABLE 8.—THE GROWTH PERIODS OF SOME IMPORTANT VARIETIES OF SOYBEANS PLANTED ON DIFFERENT DATES AT COLUMBIA.

Varieties	Early planting (May 1 to May 20) Days to mature		Mid-season planting (May 20 to June 15) Days to mature		Late planting (June 15 to July 5) Days to mature	
	Hay	Seed	Hay	Seed	Hay	Seed
Mikado	105-95	140-130	95-85	130-120	85-80	120-105
Morse	95-90	120-112	90-85	112-105	85-80	105-98
Haberlandt	95-90	120-110	90-85	110-105	85-85	105-95
Virginia	96-90	120-110	90-85	110-100	85-80	100-90
Wilson	95-87	115-105	87-80	105-98	80-72	98-90
Medium Yellow	93-88	115-105	88-82	105-98	82-75	98-90
Ito San	88-81	100-90	81-73	90-83	73-65	83-75

The necessity for the thorough preparation of the land and the clean cultivation of the crop during the growing season, if it has been planted in rows for seed, sometimes makes farmers reluctant to undertake soybean production, for by these requirements soybeans grown on a large scale will absorb considerable labor at a time when it is needed for corn. However, the labor of producing soybeans in this way is not spent wholly for their benefit. A part of the labor may be charged to wheat, if this crop follows soybeans that fall. Land which has been spring plowed and properly conditioned for soybeans, and cultivated clean during the growing season, is without further treatment an excellent seedbed for wheat. The timely removal of the soybeans is of course necessary in this rotation, but that is easily accomplished if any of the varieties recommended in this bulletin are used. Any of them will mature for harvesting well ahead of the time of seeding wheat.

INOCULATION

Soybeans, like other legumes, are benefitted by inoculation with their nitrogen gathering bacteria, especially when the soil is low in fertility and the crop is grown for the first time. Under these extreme conditions soybeans absolutely require inoculation in order to make a successful growth. On fertile soil, though grown for the first time, they can make a fairly successful growth without inoculation, but their yield is profitably increased in size and feeding value when inoculation is applied. On any soil, fertile or poor, their inoculation becomes unnecessary, at least for some time, after a crop has produced nodules abundantly. For example, on the Experiment Station field at Columbia there has been no inoculation since 1916, when a very successful crop well set with nodules was produced, yet the yields have increased since that time and the nodules have become even more abundant.

Perhaps inoculation on any part of this 30-acre field will not again prove beneficial. On the other hand, when a soil is very low in organic matter, frequent inoculation may be necessary to establish and maintain the supply of nitrogen gathering bacteria. The growth of soybeans on such soil at the Cuba experiment field (page 10) seems partly to illustrate this case. Previous to 1919, soybeans had not been grown on or near this field, and probably the extremely low yields of 1919 and 1920 were due partly to the difficulty of establishing by inoculation in that thin soil the nitrogen gathering bacteria of the soybean plant. In 1921, three years from the first attempt to grow soybeans, there was made an average yield more than double the highest previous average Probably the accumulation of soybean bacteria, as the result of several inoculations, was a very important factor in this production.

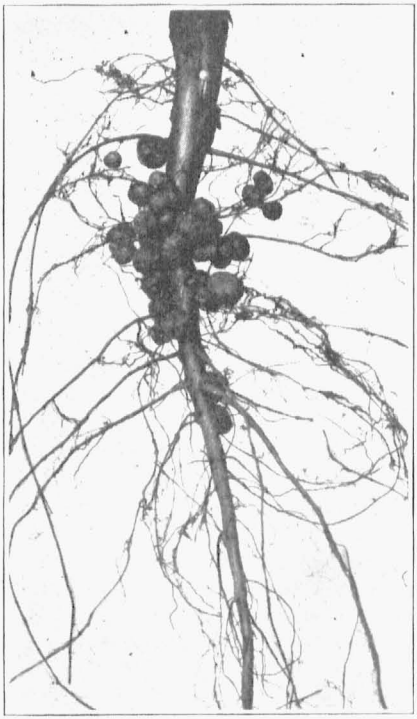

Fig. 8.—For soybeans to make their best growth their roots must be well set with nodules, the result of thorough inoculation.

A few years ago soybeans were considered one of the most difficult of legumes to inoculate successfully, but probably this was due to the inefficiency of the inoculating material then available, rather than to the difficulty of applying it. When fresh, properly made cultures are used a failure to secure effective inoculation is likely to occur only when soil conditions are extremely unfavorable. Thus, during the past year, the Department of Soils, Missouri College of Agriculture, collected from 100 farmers data on the results from inoculation with soybean cultures which the farmers had obtained from the Department. Ninety-five of these farmers reported successful inoculation, these cases being judged by increased yields and the presence of nodules on the roots of the plants. The Department of Soils will supply inoculating material for soybeans, at the small cost of preparation. When this material is used according to instructions sent with each package, one of the most important requirements of the soybean crop will have been satisfied.

FERTILIZERS, LIME AND MANURE

Although direct applications of these materials to soybeans has not been definitely tested on Missouri soils, the Department of Soils, Missouri

College of Agriculture, has acquired rather broad information on their effect in the rotation of corn, **soybeans,** wheat and clover, from the results of experiments conducted for 3 to 9 years on seven important types of soil, well distributed over the State, and representing an extremely broad range in fertility. Fertilizer, lime, or manure has been used alone or in combination, at the following acre rates:

Steamed bonemeal, 125 to 150 pounds to corn and to wheat.

Acid Phosphate, 150 to 200 pounds to corn and to wheat.

Potash (Kcl), 15 to 50 pounds to corn and to wheat.

Lime (ground limestone), 3,000 to 6,000 pounds, every fourth or sixth year, usually before wheat.

Manure, 8 tons once in four years, on clover sod before corn.

No fertilizer, lime or manure, was applied directly to soybeans; consequently this crop could be benefited only by the remaining effects of the applications to corn and wheat in the same rotation. The benefits are indicated by the following summary of results:

1. The yields of soybeans were always increased when any of the above quantities of fertilizer or lime or manure were applied to the rotation in which this crop was included.

2. The increase from the use of lime on any type of soil was not large enough to make a profit above that part of the cost of lime chargeable to the soybean crop.

3. On the more fertile soil there was no profitable increase in the yields of soybeans when the cost of any of the above applications of bonemeal, acid phosphate, and potash, was charged proportionally to this crop.

4. On soils of medium to low fertility, the above quantities of bonemeal and acid phosphate applied to corn and wheat, produced a profitable increase in the yield of soybeans in the same rotation.

5. The applications of potash produced a profitable increase in soybeans only on one soil, in which the natural supply of available potash is apparently very low. When applied in combination with bonemeal or acid phosphate, potash was not more profitable than when applied alone.

6. On all types of soil, manure applied to the clover sod preceding corn, produced a profitable increase in soybeans following corn, when a part of the cost of $1 per ton of manure was charged against them. The increase was very substantial on soils low in fertility, but small on the more fertile types.

From this summary it may be concluded that the increase in the yield of soybeans, resulting from applications of fertilizers or lime or manure to corn and wheat in the same rotation, is not likely to be large enough, except on soils of medium to low fertility, to show an important individual profit above that part of the cost of these materials which is chargeable to the soybean crop. But probably this increase will be large enough under any conditions to contribute materially to the total profit from the use of fertilizer or lime or manure in the rotation as a whole. Moreover, since soybeans bring larger cash returns than oats, and are less exhaustive to the soil, a rotation of corn, **soybeans,** wheat and clover, is likely to show larger profits from the use of fertilizer or lime or manure, than would a rotation of corn, **oats,** wheat and clover.

It may also be concluded that the direct application of fertilizers or lime or manure to soybeans not in systematic rotation with other crops, would not likely be profitable on Missouri soils, since the cost of the application would then be charged wholly or largely against the increased yield of the soybean crop.

The explanation for the general failure of these materials to produce a profitable increase in the yield of soybeans in this State is found in the simple fact that on most of our soils this crop finds natural resources sufficient for a vigorous growth.

SEEDING PRACTICES

Neither the time, rate, nor method of seeding soybeans appear to have more than a moderate influence on the success of the crop, except in extreme cases. Thus during the period May 15 to June 15, in a normal season, the success of soybeans in Central Missouri probably is not greatly influenced by planting on any particular date; likewise, within reasonable limits a small variation in the rate or method of seeding is not likely to cause a material difference in yield. But soybeans, like all other crops, have general requirements in time, rate, and method of seeding, and unless these requirements are met the crop will not make its highest or most economical production. In Tables 9 to 12 will be found data to illustrate this fact.

Time of Seeding.—Studies of the relation between the time of seeding and the yield of the soybean crop have not been extensive at this Station, but the results from an experiment conducted for 2 years indicate very clearly that serious losses in yield may follow either early or late planting. In 1916 and 1917 the Haberlandt variety was planted at dates ranging from April 7 to July 15, with the results shown in Table 9. The soil on which this experiment was located was less fertile than that given to the varieties named in Tables 1 and 2; consequently the yields are much lower. All yields in Table 9 are the average of three series of plots, each plot being one-tenth of an acre in size.

TABLE 9.—ACRE YIELDS IN BUSHELS OF SOYBEAN SEED AND TONS OF HAY FROM PLANTING ON DIFFERENT DATES.

Date of planting	1916		1917	
	Seed	Hay	Seed	Hay
April 7	0.0	0.0	7.5	0.57
April 15	0.0	0.0	7.6	0.66
Average of April	**0.0**	**0.0**	**7.6**	**0.62**
May 1	5.4	0.89	10.9	0.93
May 15	5.0	0.97	13.3	1.20
Average of May	**5.2**	**0.93**	**12.1**	**1.10**
June 1	7.0	1.6	14.7	1.10
June 15	7.1	1.4	14.8	1.20
Average of June	**7.1**	**1.5**	**14.8**	**1.40**
July 1	5.5	0.65	7.3	1.00
July 15	3.1	0.76	1.4	.34
Average of July	**4.3**	**0.71**	**4.4**	**.65**

These results show at a glance that the planting period June 1 to June 15 was more favorable than any other, for the production of both seed and hay. The yields from May planting were fairly good, but those from April and July planting were very poor—the April planting of 1916 being a complete loss, because of its failure to germinate.

The general success of planting soybeans early in June has been repeatedly observed in other experiments which were not designed to deal with this particular problem; it has also been observed by many practical growers. Soybeans germinate and grow very poorly in either a cold soil or a dry soil; moreover there is danger that an early fall will prevent the full maturity of the seed in a crop planted as late as July 1. Near the first of June the soil will generally be found in the most favorable condition of heat and moisture for the good germination and rapid growth of this crop; and there seems but little doubt that in most seasons better yields will result from planting at this period than from planting earlier or later. From South Missouri to North Missouri the most favorable date of planting will probably range from May 20 to June 10, when any of the varieties recommended in this bulletin are to be grown.

Depth of Seeding.—No experiments have been conducted by the Missouri Experiment Station to find the relation between the depth of planting and the yield. But that such a relation does exist, within rather narrow limits, is clearly shown by the results of studies conducted by the Office of Forage Investigations of the United States Department of Agriculture. Unless soybeans are planted very shallow a serious loss in stand may result. Apparently the soybean seedling lacks sufficient strength to push itself through a heavy covering of soil. The most favorable depth will vary somewhat with the character of the soil, being very shallow for heavy soils and deeper for light soils. In general 2 inches is a very favorable depth, although on light soils probably there would be no damage from planting somewhat deeper.

Rate and Method of Seeding.—The effects of the rate of seeding and the method of seeding upon yield must be considered jointly, for under extreme conditions they are related. In Table 10 are the results from drilling the Haberlandt variety at rates ranging from 45 to 105 pounds of seed to the acre, during the years 1912 to 1915. The experimental plots were one-twentieth of an acre in size, were located on fairly uniform upland soil of about average fertility, and the yields represent the average production of four plots.

TABLE 10.—YIELDS OF SOYBEAN HAY FROM DRILLING DIFFERENT QUANTITIES OF SEED IN 8-INCH ROWS.

Pounds of seed drilled per acre	Tons of hay per acre				
	1912	1913	1914	1915	Average
45	2.4	1.1	2.2	2.9	2.1
65	2.5	1.0	1.5	1.9	1.7
85	2.3	1.2	1.1	2.1	1.7
105	2.2	1.4	1.8	2.4	1.9

It is readily seen from this Table that varying the rate of seeding in 8-inch rows, from 45 to 105 pounds to the acre, had no consistent effect upon yield. Since all of these quantities are within the range of seeding rates some times recommended for drilling or broadcasting a crop of soybean hay, it is important to observe that 45 pounds of seed to the acre produced as much or even more hay than was produced by any greater rate of seeding up to 105 pounds.

In 1912 to 1916 there was conducted an experiment to determine the joint effect of varying the rate of seeding and the width of the row upon yield. The Morse variety was planted at rates ranging from 30 to 60 pounds of seed to the acre, in rows ranging from 8 to 40 inches wide. In uniformity and fertility the soil was about the average of Missouri upland. There were three series of plots, each plot being one-tenth of an acre in size. The yields reported in Table 11 are the average production of three plots.

TABLE 11.—YIELDS OF SOYBEAN HAY FROM DIFFERENT RATES OF PLANTING AND ROWS OF DIFFERENT WIDTHS.

Pounds of seed planted to the acre	Distance between rows *inches*	Tons of field cured hay to the acre					
		1912	1913	1914	1915	1916	Average
60	8	1.5	1.5	2.8	3.1	2.3	2.3
60	16	1.6	1.3	2.5	2.5	2.1	2.0
40	24	1.4	1.1	2.6	1.7	1.8	1.7
40	32	1.4	1.3	2.3	1.9	2.0	1.8
30	40	1.2	1.3	2.0	1.7	2.0	1.6

The results in this Table show that 60 pounds of seed to the acre in 8-inch rows made higher yields than were made by 60 pounds of seed in 16-inch rows, or 40 pounds of seed in 24-inch and 32-inch rows, or 30 pounds of seed in 40-inch rows. Briefly, the heavy rate of seeding in close-spaced rows made higher yields than comparatively low rates of seeding in wide-spaced rows. But in Table 10 a rather wide variation in the rate of seeding had no apparent effect on yield, when different quantities of seed were each planted in rows of the **same width** (8-inch drill rows). Therefore the results in Table 11 suggests that the manner of **distributing** the seed—that is, the different spacing of the rows—rather than the quantity of seed used, was the factor which most influenced yield. For high yields of hay the advantage of a thorough distribution of the seed by means of close-spaced rows is therefore indicated.

In 1918 a further study of the joint effect of varying the rate of seeding and the width of the row was begun. The Wilson variety was planted in rows ranging from 42 inches to 8 inches apart and at rates ranging from 15 to 90 pounds to the acre. The soil on which the experiment was located was hardly so fertile as the average upland. The plots were one-tenth of an acre in size and each yield given in Table 12 represents the average production of three plots.

TABLE 12.—ACRE YIELDS IN BUSHELS OF SOYBEAN SEED AND TONS OF HAY FROM DIFFERENT RATES OF PLANTING AND ROWS OF DIFFERENT WIDTHS, IN 1918.

Pounds of seed planted to the acre	Distance between the rows							
	42 inches		32 inches		16 inches		8 inches	
	Seed	Hay	Seed	Hay	Seed	Hay	Seed	Hay
15	11.5	1.8	11.3	1.7	9.8	1.2	.....	.....
20	12.7	1.8	11.9	1.8	9.9	1.4	.....	.....
25	11.4	1.5	11.0	1.8	10.0	1.4	.....	.....
30	11.3	1.6	11.1	1.5	9.0	1.3	.....	.....
40	.....	....	.....	....	.....	....	2.0	2.1
50	.....	....	.....	....	.....	....	1.9	2.1
60	.....	....	.....	....	.....	....	2.4	2.6
90	.....	....	.....	....	.....	....	2.0	2.0

When the results shown in this table are properly interpreted they strongly support those in Tables 10 and 11. There were no significant differences in yield from varying the rate of seeding in rows of a certain width. (See also Table 10). In 42-inch rows the yields from planting 15 to 30 pounds of seed to the acre are very similar; likewise, in 32-inch, 16-inch, and 8-inch rows no significant variation in yield follows a variation in the seeding rate. Again, the yield of hay in the heavily sown 8-inch rows was higher than the yields in any wider spaced rows, sown at lower rates. (See also Table 11). And finally, the low yields of seed in the close-spaced rows illustrate the extremely important fact that while close spacing may increase the total weight of hay produced, it decreases the yield of seed and thus lowers the feeding value of the hay.

A few practical applications may now be stated from the results shown in Tables 10, 11, and 12.

First.—When the soybean crop is planted in wide-spaced rows or in close-spaced rows, the rate of seeding under either condition is not of primary importance, provided a reasonable quantity of seed is used.

Second.—A heavy rate of seeding in **close-spaced** rows is likely to produce a higher yield of hay than a light rate of seeding in **wide-spaced** rows, if in each kind of a row a quantity of seed suitable to the land is used. The more fertile the land the heavier the required quantity of seed; therefore no certain quantity is best for all types of soil. These experiments indicate that on upland soil, near the average in fertility, there will be no gain in using more than 3 pecks of seed to the acre, in 8-inch drill rows. A heavier rate of seeding may, however, result in a smaller growth of weeds and therefore cleaner hay.

Third.—A crop grown in close-spaced rows will make a comparatively light yield of seed; consequently, the quality of the hay will be lower than that of the heavily seeded crop in wide-spaced rows. But on the other hand hay grown in wide-spaced rows will be more difficult to cure on account of its coarser stems, and will have been far more expensive to produce, because of the labor used in its cultivation. All things considered drilling a crop of soybean hay in 8-inch rows seems the more practical method of production on soils of medium to high fertility. On soils so poor

that close spacing of the plants would result in a dwarfed growth, wide spacing of the rows would doubtless be the better method, for the growth in close-spaced rows might be so short that little of it could be secured in harvesting.

Fourth.—The results in Table 12 indicate that on the average upland soil, 1 peck (15 pounds) of seed to the acre will produce as good yields of seed as will 2 pecks (30 pounds) in rows of the same width. It is not likely that rates exceeding 2 pecks would increase the yield of seed, although it seems probable that more than 1 peck would be suitable for very fertile soils. The width of the rows for a seed crop is within limits determined largely by the convenience and economy of cultivation. Ordinary 2-horse implements can hardly be used in rows spaced closer than 32 inches; and for the economy of time in cultivation even a wider row is desirable. However, there must be some limitation on the width of the row, for if the rows are so wide that the land is not fully utilized by the crop a loss in yield must necessarily result. No certain spacing of the rows will be found the most suitable for all types of soil, but rows 3 feet apart on fertile soils and 42 to 44 inches apart on medium fertile and poor soils, will be found satisfactory.

CULTIVATION

Soybeans require clean cultivation. They do not shade the ground so thoroughly as cowpeas and consequently do not hinder the growth of weeds so well; nor can they compete with a growth of weeds already present, even so well as corn. No doubt insufficient cultivation is one of the most common causes of occasional failures with this crop.

The first step in cultivating the soybean crop is to plant it shallow on clean, lately prepared land, to gain for it a start on weed growth. If the soil is heavy and forms a hard crust after a beating rain, a light harrowing to break this crust and allow the crop to come up, and at the same time to destroy the beginning of weed growth, will be of great benefit. Harrowing may be repeated once or twice when the plants are about 4 inches tall. It is beneficial when the crop is planted in any manner—drilled, broadcast, or in wide-spaced rows. Harrowing the thickly sown crop will result in larger yields of clean hay; harrowing the rowed crop will reduce later work with the shovel cultivator. In using the harrow its teeth should be slanted slightly backward and the cultivation should run diagonally across the rows.

Later cultivations—usually two to four are necessary—may be made with the ordinary four or six shovel cultivators, as in the cultivation of corn. However, better results sometimes follow the use of the disk cultivator, especially if the crop has been planted early and the land is cold and wet. Under this condition the first cultivation should bar off the rows, going close to the plants and leaving them on a narrow ridge. This makes a better drained and warmer soil around the plants, to a depth of about 3 inches.

The second cultivation should throw the soil back to the plants, cover the weed growth and leave the ground level. Succeeding cultivations should be level if the crop is to be harvested with a mower, but should

leave a slight ridge if a binder is to be used. By running the binder wheels between the ridges it is possible to set the platform nearer to the ground, with less forward tilting of the machine, and thus to harvest the crop more efficiently. But high ridges should never be formed, for these would make harvesting impossible with any machinery ordinarily used in this State.

Cultivation should end just before the crop reaches full bloom. If continued beyond that stage many blossoms will be destroyed and consequently the yield of seed reduced. And it should finally be emphasized that soybeans should never be cultivated when they are tender from rain or dew, for in that condition they are easily broken or bruised.

Fig. 9.—A successful seed crop of soybeans must be grown in wide-spaced rows and cultivated **clean.**

HARVESTING, THRESHING AND STORING SOYBEAN SEED

Harvesting is probably the greatest difficulty in the production of a crop of soybean seed, because of the losses from shattering. Unless the crop is handled at the right stage these losses may be large enough to discourage the grower. Harvesting should begin soon after the pods have completely turned color. If the crop is allowed to stand until all the leaves have fallen and the pods have thoroughly dried, there will be losses from shattering with even the most careful harvesting.

Soybeans may be harvested with either a mower or a binder. When the mower is used, a buncher attachment on the sickle-bar is desirable. In any case it will pay to follow the machine and fork the swath into bunches away from the land to allow clearance for the next round. This requires considerable hand labor, but it is much better than mowing and windrowing with a sulky rake.

Harvesting with a grain binder and shocking or stacking the beans like wheat or oats, is much better than mowing. The binder platform must

be lowered as far as possible, and then by tilting the binder forward the crop can be cut within 4 inches of the ground. When the rows have been slightly ridged the crop can be cut lower with less tilting of the machine. If the crop has lodged badly, extension guards bolted to the sickle-bar so that they will come between the rows and pick up and drop the lodged plants on the canvas platform, will make harvesting much more efficient. The guards may be made of iron rods about ½ inch in diameter and 10 to 18 inches long. They should be bent slightly upward at the outer end. The bundles of beans should be tied loosely; tight bundles will lose more seed by shattering and also may mould inside. The tying may be loosened by reducing the tension on the bundle trip.

After harvesting the crop should be shocked and capped in about the same way as wheat. It should stand in the shock for 10 days or more before stacking and for at least two weeks before threshing. Usually it

Fig. 10.—Soybeans in the shock after harvesting with a grain binder.

is better to stack soybeans than to thresh them from the shock. They are likely to be damaged by shattering or weathering if left in the shock long after they are cured, but when once in the stack they are safe from the usual rainy weather of late summer or early fall, and can be threshed at the convenience of the farmer.

The stacks should be built long and narrow, keeping a full center and placing the bundles with the butts out. But even when a soybean stack is well rounded it does not shed water well, because of the coarseness of the stems, and it should be covered with straw or coarse hay. Threshing will be much more efficient if the beans are allowed to dry out thoroughly in the stack, which will require a month to six weeks of ordinary fall weather.

Threshing.—Soybeans can be threshed more efficiently with a pea and bean separator than by any other means. With this machine there will be a minimum of unthreshed and split seed. However, an ordinary grain sep-

arator, properly adjusted, will thresh the crop very well. By the use of two special pulleys, the speed of the cylinder should be reduced to 300 or 400 revolutions per minute, and the fan, shaker and screens run at normal speed. In addition, about half the cylinder teeth and all the concaves should be removed, substituting boards for the latter. Each of these adjustments should vary somewhat with the variety and the condition of the beans. When the whole crop is of the same variety and is well cured, the grain separator can be adjusted to do a very satisfactory job. The oats screens should be used for all varieties.

A machine with a slatted straw carrier is more satisfactory for this purpose than one with a wind stacker. Soybean straw will frequently choke the latter type at the junction of the stacker tube and the body of the separator.

Special attachments for threshing peas and beans may now be obtained for nearly all standard separators. And since only a low cylinder speed is required in this work many old separators no longer serviceable for threshing oats and wheat may be rebuilt, equipped with these attachments, and last for years as a soybean thresher.

Storing.—Unless soybeans seed is properly cured and stored it is likely to heat and quickly lose its power to germinate. In fact good soybean seed over one year old is not easy to find. The following data selected from the experiments of Piper* will illustrate this fact by showing germination percentages at different ages.

Variety	1 year old per cent	2 years old per cent	4 years old per cent
Shanghai	99.0	93.0	43.5
Chernie	94.0	76.5	46.5
Jet	92.5	60.0	19.5
Guelph	97.5	86.5	1.5
Haberlandt	76.0	2.5	0.0
Mammoth	77.0	32.5	0.5

Clearly there is a wide difference in the ability of varieties to retain their germinating power and this is a matter to be given serious consideration in choosing a variety for the production of seed for planting. But the seed of any variety should be carefully stored, for it is likely to lose much of its value from heating.

Although the exact conditions of storage under which soybean seed will keep best are not known, it certainly should not be stored in bins immediately after threshing. The Experiment Station has found that when the stack-cured seed are sacked just after threshing and piled in a way that will make large air spaces between the sacks, the seed will keep very well; but seed stored at once in large bins will lose considerable germinating power by spring. In sacking the seed for storage, burlap or jute sacks are better than cotton sacks, for they more readily allow air to reach the seed; also the sacked seed should be piled in a well ventilated room. A small quantity of seed might be safely stored in a bin if first thoroughly cured, which may

*Piper, C. V., Forage Plants and Their Culture, page 535.

be done by spreading it on a floor, in layers 8 or 10 inches deep and stirring it occasionally, for two or three weeks of fairly dry weather.

Unless soybean seed is known to have been properly stored, it should be bought only under a guarantee of germination, and even then it should be tested for germination before planting. Two years ago a certain Missouri community bought a large lot of soybean seed from the same source and found the whole lot to be nearly worthless on account of its low germination.

SOYBEANS AS A HAY CROP

The popularity of soybeans as a seed crop has caused their fine possibilities for the production of hay to be generally overlooked in this State. They can be sown as a full season crop, taking the place of a failure of clover or a bad stand of corn, or as a mid-season catch crop after wheat, always with good results, if properly treated. On land unsuitable for alfalfa, they will produce fine crops of legume hay fully equal to alfalfa in feeding value. An example of the comparative yields of alfalfa and soybeans on average upland soil was found in 1920 at the Missouri Experiment Station. Alfalfa which had been highly treated with lime, fertilizer and manure, made a total season's yield of less than 2 tons to the acre, while a field of soybeans planted in rows on similar soil, separated from the alfalfa by only a 16-foot roadway, made nearly 4 tons from one cutting, with no treatment except clean cultivation and good preparation of the seedbed.

The general methods of producing soybean hay have already been discussed under the heads of "Seeding Practices", pages 20 to 24 and "Cultivation", pages 24 and 25. But special attention must be given the subjects of catch crops, harvesting and curing.

Soybean Catch Crops Following Grain.—The production of late feed crops (catch crops) on wheat or oats stubble is not a common practice in most parts of Missouri. But the results of recent tests at the Missouri Experiment Station indicate some good possibilities in catch crops on upland soils, which seem not to have been realized previously.

In the first place, what crops can be sown on the grain stubble of average upland soil with a reasonable chance for success? Cowpeas, soybeans, Sudan grass, sorghum, and millet can all be used. But the non-legumes—Sudan grass, sorghum and millet—are generally much less desirable than cowpeas or soybeans. They leave the land in rather bad condition, especially for seeding another wheat crop in the fall, and though they might produce a large bulk, their forage is much lower in feeding value than that produced by cowpeas or soybeans. The only point in favor of Sudan grass, sorghum, and millet as catch crops after wheat or oats, is that their seed is comparatively cheap and easy to obtain; hence they may at times be more practical than cowpeas or soybeans for use on a large scale. Millet may be sown later than any other crop, and is sometimes chosen for this reason alone. But under any ordinary conditions of seed prices, time of sowing, and scale of production—and considering the value of the feed and the effect of the crop on the land—cowpeas or soybeans make a far more satisfactory catch crop than the non-legumes mentioned.

With some preparation of the grain stubble, catch crops of cowpeas or soybeans, worth a considerable part of the previous grain crop, can be produced.

For the most successful production on average upland soil the land must be plowed and in most cases rolled or disked. The beans or peas should be seeded as early as the grain crop can be removed from the land. If the grain cannot be threshed within two or three weeks after harvesting, that part of it on the land intended for the catch crop should be stacked or the shocks should be lined up to permit plowing. In the average season this will make possible the seeding of the beans or peas at a date early enough to permit a good growth that can be cut for hay in time to seed wheat on the same land that fall. If wheat is to follow the catch crop, soybeans are more satisfactory than cowpeas, for they leave the land in

Fig. 11.—This crop of soybean hay sown after wheat, yielded 1.5 tons to the acre.

better condition as a seed bed for wheat. In fact, if the grain stubble is plowed and disked for the soybeans, little or no preparation of the land for wheat after the soybean hay is removed, will be necessary. The effect of soybeans in loosening the soil will do much to improve its mechanical condition. Cowpeas have a similar but more pronounced effect. Generally they are likely to loosen the soil so much that the pea stubble must be rolled if the best seed bed for wheat is to be obtained. It should be remembered that winter killing is more severe when the seed bed is very loose. Finally, soybean hay is much easier to cure than cowpea hay.

The benefit from good preparation of the land for the soybean catch crop has been very marked, as shown by the results in Table 13. When the grain stubble was plowed and disked there was always a fine thrifty growth of soybeans, which reached the hay stage in ample time to be followed by wheat. The acre-yield was never less than one ton of clean hay, worth as much as a ton of alfalfa. On the other hand when the stubble

was given no preparation except disking and harrowing, the average yield was comparatively poor both in quantity and quality. However, where plowing is not practicable, double disking and harrowing the grain stubble is to be recommended. The resulting catch crop will always pay for the labor and expense involved.

A ton of clean soybean hay to the acre between the two grain crops (wheat and wheat, or oats and wheat) will pay a good profit. And the land is nearly or quite ready for seeding wheat in the fall, when the catch crop is

Fig. 12.—On the right, a soybean catch on plowed and disked grain stubble; on the left, the same crop on grain stubble disked only. Note the difference in the quality of the hay.

cut. In fact, if the preparation for both crops is considered, the only items which can accurately be charged against the catch crop are the costs of the seed, sowing, and handling the hay.

A final point in favor of the catch crop, which cannot be calculated, is its effect in controlling weeds, which thrive when the land is idle. When stubble land waits for fall plowing, or when it is plowed in the summer and stands idle until its preparation for fall seeding, it nearly always becomes badly infested with weeds, the seeds of which are disseminated over the

Table 13.—Yields of Soybean Hay Grown as a Catch Crop After Wheat.

Treatment of the wheat stubble	Tons of cured hay to the acre			
	1919 (seeded July 22)	1920 (seeded July 17)	1921 (seeded June 28)	Average
Double disked and harrowed	0.50	0.90	1.50	0.97
Plowed, double disked and harrowed	1.20	1.00	1.90	1.37

whole farm. Heavy catch crops of cowpeas or soybeans on the grain stubble, together with clean cultivation of corn, will solve the weed problem on cultivated land and will result in a higher production for the farm as a whole.

Harvesting and Curing Soybean Hay.—Soybeans are much easier to harvest for hay than cowpeas. They grow erect, do not tangle like cowpeas, and cure more rapidly. The best stage at which to harvest a hay crop of soybeans to secure the highest feeding value from the acre is not exactly known, and it could be determined only by feeding tests of hay cut at various stages of growth. However, if the crop is cut when the pods are plump with seed, but before they begin to turn their color, the hay will

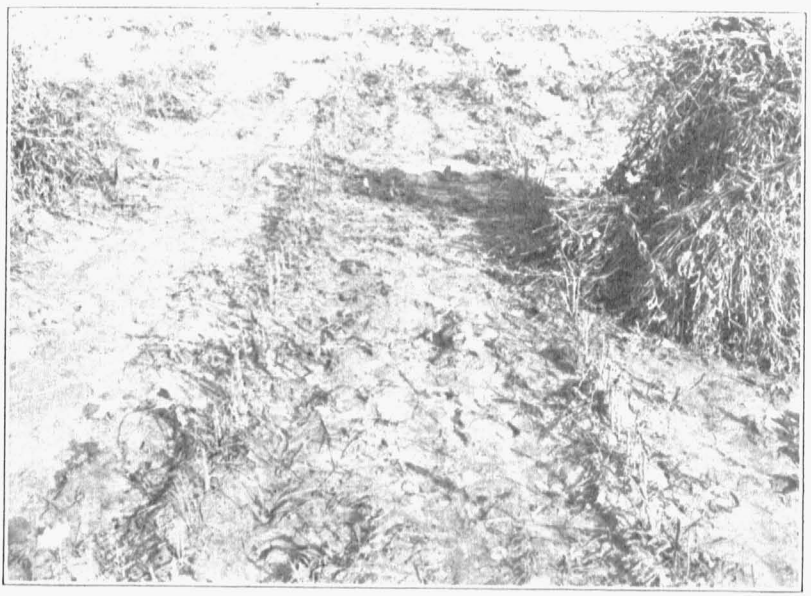

Fig. 13.—After a spring plowed and clean cultivated crop of soybeans, the soil is in excellent condition for seeding wheat—mellow, fine and firm.

be found satisfactory. Later than this the stems become woody, the leaves fall, and the crop rapidly loses value as hay. Earlier, the hay may be higher in quality, but lower in yield.

The best way to harvest soybean hay is to mow it down like grass or clover.

Soybean hay is easy to cure when the growth is not too woody and the weather very favorable. Under these conditions the crop should be cut in the morning, after the dew has dried, allowed to wilt in the swath until late that afternoon, and then forked into small cocks to cure slowly. Too rapid curing will cause many of the leaves to drop, thus losing much of the value of the hay. But fair weather is not likely to prevail for long periods in late August and early September, the time when soybeans generally reach the hay stage; consequently it will usually be necessary to partly cure the hay

in windrows after it has wilted in the swath. Curing may then be completed in somewhat larger cocks than when no windrows are used. Three or four days of fairly good weather is ordinarily the time required to cure soybean hay properly. When a handful can be strongly twisted without giving moisture from the stems it is safe to stack or house. Slow curing to prevent rapid drying and shattering of the leaves is very desirable.

There are no rules for curing soybean hay in unfavorable weather. The process to be followed must then be determined by judgment. In extremely unfavorable conditions "brown curing" may become necessary. This is the very simple process of piling the green hay in rather large compact cocks and allowing it to cure by its own heat. The market value of the hay will be greatly reduced by this process, but its actual feeding value will nearly equal that of sun cured hay.

SOYBEANS IN THE CROP ROTATION

Soybeans fit perfectly in the place of oats, thus making a four year rotation of corn, soybeans, wheat and clover. The chief advantages of substituting soybeans for oats are (1) soybeans are far more profitable as a cash crop and (2) they leave the soil in better condition. Much of the labor spent on the soybean crop may be utilized as preparation of the land for the following crop of wheat. When land is plowed in the spring for soybeans and the crop is well cultivated during its growing season, the bean stubble is an excellent seed bed for wheat, with little or no further preparation. (Fig. 13.) In the seasons of 1917, 1918 and 1919, soybean stubble was treated in various ways to prepare it for seeding wheat. Each treatment was made on duplicate plots one-fourth of an acre in size. In Table 14 are shown the yields of wheat resulting from the different treatments, each yield being the average of duplicate plots.

TABLE 14.—ACRE YIELDS IN BUSHELS OF WHEAT FROM DIFFERENT TREATMENTS OF SOYBEAN STUBBLE.

Year	No treatment	Harrowed	Single disked	Double disked	Single disked harrowed	Double disked harrowed	Double disked rolled
1917-18	23.1	22.3	21.9	22.6	24.4	21.2	26.1
1918-19	15.6	13.5	13.9	15.6	14.6	16.1	14.7
1919-20	23.6	24.4	21.5	22.4	28.5	25.4	29.0
Average	20.8	20.1	19.1	20.2	22.5	20.9	23.3
Average difference		-0.7	-1.7	-0.6	1.7	0.1	2.5

The results do not show that even the best of the treatments were very effective. The most productive treatment was double disking and rolling, which showed an average acre gain of 2.5 bushels over the untreated stubble. But this was barely enough to pay for the cost of the treatment, and so it must be concluded that on average upland loam soil the treatment of soybean stubble in preparation for wheat is not likely to be profitable, if in the production of the soybean crop the land has been properly handled. It is well to note that during the same seasons, wheat sown on **well prepared** oats stubble made an average acre yield of 21.0 bushels, while the average yield on **untreated** soybean stubble was 20.8 bushels.