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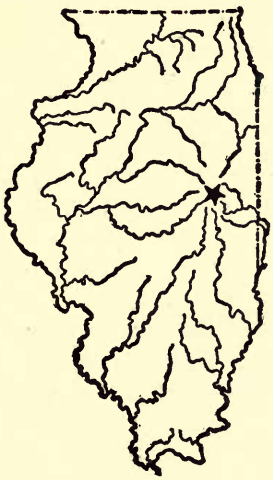
SOYBEAN PRODUCTION IN ILLINOIS

By J. C. Hackleman, O. H. Sears, and W. L. Burlison



URBANA, ILLINOIS, JUNE, 1928

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SOYBEAN PRODUCTION IN ILLINOIS

By J. C. Hackleman, Chief in Crops Extension; O. H. Sears, Assistant Chief in Soil Biology; W. L. Burlison, Chief in Crop Production and Head of Department of Agronomy[a]

During the past ten years soybeans have found a significant place in corn-belt farming. They have spread in acreage and popularity more rapidly than has any other field crop in Illinois in recent years. This statement is borne out by the fact that in 1914 there were harvested in the state, in one form or another, about 2,000 acres. Thirteen years later, in 1927, the acreage had jumped to 776,000.[b] The crop has so many points of economic importance in its favor that it will doubtless continue to be extensively grown.

With hundreds of farmers annually trying out soybeans for the first time, with the increased interest in the crop resulting from continued economic difficulties with the oat crop, and the threatened invasion of the corn borer, problems regarding the soybean are constantly coming up with renewed vigor. Farmers wish to know the various uses to which the new crop can be put, its adaptation to their sections of the state, and particularly urgent is the demand for recommendations regarding suitable varieties and the details of cultural practices.

This bulletin is therefore issued principally to report the results of variety trials which have been under way on the University South Farm at Urbana for about twenty years and on the northern Illinois experiment field at DeKalb for five years. The most recent information available on other points of interest is also included in order that farmers and others may have a good basis for arriving at a correct evaluation of the crop.

SEEDING PRACTICES IN ILLINOIS

Two different planting methods are followed in Illinois: the beans are grown alone for seed or hay or they are grown with corn or some other crop to be put into the silo or to be pastured off. The acreage in the state, as reported by the Bureau of Agricultural Economics of the U. S. Department of Agriculture, is given separately for these two kinds of production. A study of the map on the next page shows the different farm uses of the crop in the various sections of the state.

The practice of seeding soybeans with corn predominates in the dairy section of northern Illinois, in the cattle feeding section of

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[a]The authors are indebted to Mr. C. L. Meharry, of Attica, Indiana, and Mr. J. C. Allen, of West Lafayette, for the use of Figs. 4, 5, 7, 8, 9, 10, and 12 in the following pages.

[b]The area planted for seed and hay was 419,000 acres; the area planted with other crops was 357,000 acres.

northern and northwestern Illinois, and in the hog feeding area of west-central Illinois. In the west-southwestern area, where considerable dairying is practiced, the acreage planted for hay and seed is less than

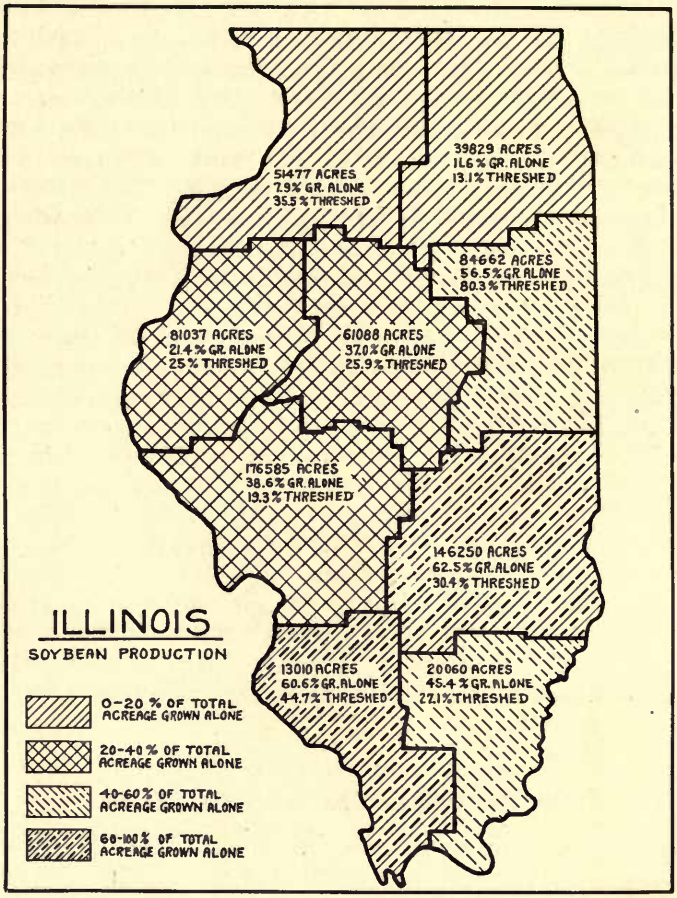

FIG. 1.—DISTRIBUTION OF SOYBEANS IN ILLINOIS 1923 TO 1926 INCLUSIVE

the acreage planted to a mixture of soybeans and corn, the proportion being three acres in corn to two grown alone.

The growing of soybeans alone predominates in the east-central, in the east-southeastern, in the southeastern, and in the southwestern areas. In the east-central area the crop is grown primarily for seed, approximately 80 percent of the acreage grown alone being threshed. In the east-southeast area it is used primarily for hay, only 30 percent of the acreage grown alone being threshed. In the southeast area

only 27 percent of the acreage grown alone is threshed. In the southwest area 60 percent of the acreage is grown alone and of this 44 percent is threshed.

These figures indicate that the practice of growing soybeans alone as one of the major rotation crops is now, as it probably will continue to be, confined largely to those areas where the oat crop has long been considered a cash grain. On the light-colored soils of southern Illinois, where applications of limestone in relatively large quantities are essential for clover and alfalfa production, the acid tolerance of the soybean will probably tend to encourage the culture of this crop. While seed production in those regions will doubtless increase in importance, the recognized necessity for a leguminous roughage will probably cause the crop to remain chiefly a hay crop. In the northern, northwestern, and western areas of the state, where oats and barley are relatively better producers and where these grains can be utilized on the farms, and where clovers and alfalfa can be grown with less outlay in soil improvement, the soybean will probably continue to be considered as an emergency hay crop to be used in seasons when other legume hays fail.

Soybean seed production in Illinois will probably continue to be concentrated in the grain-farming areas of the central, east-central, and east south-central sections of the state, where the crop is used largely as a substitute for oats, altho there undoubtedly will be some increase in the northern regions in the proportion of the crop grown for seed as higher yielding early varieties are developed and as more satisfactory harvesting machinery becomes generally available.

SOME REASONS FOR POPULARITY OF THE SOYBEAN IN ILLINOIS

The soybean has at least six valuable characteristics which have influenced farmers of this state to turn to it during recent years. Without reference to their relative importance, the advantages may be enumerated as follows:

It is the richest protein-producing grain on the Illinois farm.
It is the richest nitrogenous roughage adapted to most farms.
It is adapted to many uses and relished by most livestock.
If properly handled it furnishes a satisfactory substitute for oats in the cropping system and is a good emergency hay crop.
It is adapted to a wide range of soil types.
Being a legume, it has merit as a soil builder if used properly.
It ranks well as a cash crop.
It fits well into Illinois rotations.

A Valuable Nitrogenous Feed

The soybean has a distinct advantage over most legumes in that it may be planted with corn to be used either for pasture or for silage.

In case the corn and beans are cut for silage, that portion of the plants left in the field can be pastured, the stock picking up the shattered seed. This seed will function as a protein supplement, replacing expensive purchased feeds. Unfortunately far too few farmers have found it possible to purchase the commercial nitrogenous concentrate necessary to balance the farm-grown cereals. The soybean, therefore, must be considered, not solely as a substitute for some nitrogenous concentrate, but in reality as a home-grown nitrogenous concentrate which can be made available on farms where little or no such concentrate is being used.

Soybean seed has 664 pounds of digestible protein per ton,[8*] 276 pounds more than cowpeas, its closest Illinois competitor. This is more than three times the protein content of any other commonly grown Illinois farm grain and more than four times the protein content of corn. This would indicate that soybeans can well be utilized in the corn belt to supplement the corn ration.

Investigators are practically unanimous in their conclusions that it is feasible to substitute soybean seed for at least a portion of the nitrogenous concentrate in feeding cattle, hogs, and sheep. Among the common nitrogenous feeds soybeans rank next to cottonseed meal in digestible protein. They have a protein content equal to linseed oil meal and in quality of protein are said to be superior because they contain more of the amino acids which are necessary for growth. To be sure, neither soybeans nor soybean meal is equal to tankage in swine feeding trials. It is possible, however, to use either the seed or the meal as a substitute for a portion of the tankage requirement.

The soybean shows up well as a hay crop. It is probably for this use more than for any other that it is appreciated. It is capable of producing satisfactory yields of a highly nitrogenous hay which is the equal, pound for pound of feed consumed, of alfalfa hay.

Feeding trials at the Illinois,[12, 4, 11*] Indiana,[6, 13*] Iowa,[5, 15*] Maryland,[16*] Mississippi,[19*] Missouri,[26*] Ohio,[7*] and South Dakota[21*] Agricultural Experiment Stations bear out the above statements concerning the value of the soybean, whether in the form of seed or hay, as a nitrogenous feed. In many cases the value per unit of feed consumed is so nearly the same as that of the concentrate to which it is compared that the difference cannot be said to be significant. Another point which the farmer cannot afford to overlook is the fact that the soybean, when properly used, is almost uniformly good for all classes of livestock.

In practically all feeding experiments slightly more soybean hay is required per unit of growth than is required in the case of alfalfa. There is somewhat more wastage in feeding soybean hay because the coarser portions of the plant are often refused by animals. Considerable variation in quality has been noted in different lots of soybean

hay. This suggests the possibility of improving the quality of soybean hay and thus increasing its feeding value.

Illinois Experiments Demonstrate Feeding Value

For Horses.—Soybean hay has been utilized in numerous feeding trials of the Department of Animal Husbandry of the Illinois Station. In one experiment[4*] it was fed to purebred Percheron fillies from weanlings until they were two years old. During this period it was the sole leguminous roughage in the winter ration. The fillies made a thrifty growth and came thru the winter in good condition on an average feed cost of 14 cents a day.

For Sheep.—In sheep feeding[12*] also soybean hay has demonstrated its value. Lambs from western ewes fed soybean hay were as strong as those from ewes fed alfalfa, altho the amount of hay required was a little greater in the case of the soybeans. When compared with alfalfa hay in a ration for fattening lambs, soybean hay proved satisfactory. Kammlade and Mackey state: "In these experiments with western lambs, with corn at 65 cents a bushel and alfalfa at $20 a ton, soybean hay had a value of approximately $17 a ton for fattening lambs. With the same prices for corn and alfalfa hay and $50 a ton for the nitrogenous supplements, soybean straw for fattening lambs was worth about $5 a ton."

For Hogs.—In a ration for fattening hogs soybean oil meal, when supplemented with a simple mineral mixture[11*] consisting of equal parts, by weight, of ground limestone, steamed bone meal, and common salt, has proved of value as a nitrogenous concentrate replacing tankage. Recent investigations have shown that the feeding of whole or ground beans, in amounts sufficient to balance the corn, will result in soft pork. The use of soybean meal from which most of the oil has been removed does away largely with this danger.

For Dairy Cows.—That soybean hay which contains well-developed beans is an excellent and very palatable feed for dairy cows has been shown by investigations of the Department of Dairy Husbandry at this Station. In milk-production studies it was found to be equivalent to alfalfa hay of like quality when considered on the basis of the hay actually consumed. The wastage in the soybean hay amounted to 10 to 15 percent and consisted of the coarse stems, while the alfalfa hay was practically all consumed.

Ground soybeans and linseed oil meal proved equally valuable, pound for pound, as protein supplements for milk production, but they did not prove so palatable as soybean oil meal. Soybean oil meal and cottonseed meal of approximately the same protein content were practically equal in value for this purpose. The Ohio Experiment Station[20*] has likewise found soybean oil meal and linseed oil meal prac-

tically equal in the rations of dairy cows, the soybean oil meal showing 2 percent better milk production than the linseed oil meal.

A Satisfactory Substitute for Oats and a Good Emergency Hay Crop

When attempting to determine the proper place for soybeans on an Illinois farm, the crop should not be considered as a grain crop competing with corn. Soybeans appear more nearly in their proper place in Illinois when considered as a substitute for oats or as an emergency hay crop. From this point of view the crop has a future on most Illinois farms. Those who are seeking a crop that will permit them to make some changes in their farming system are giving consideration to the soybean.

There is probably no crop on the farms of the state that responds more readily to good cultural practices or is capable of failing more completely because of lack of good care than the soybean. Single crop yields of 30 to 35 bushels an acre and five-year average yields of 22 to 25 bushels are not unusual on farms where the grower is familiar with the art of producing the crop.

The average yield of 67 seed crops from 22 varieties tested in the South-Central rotation on the University South Farm in the past five years (1922-1926) was 23.7 bushels, and this in a rotation that is recognized as a poor one, consisting of corn, corn, corn, and soybeans. The poorest average yield for a period of at least three years for any single variety was 14.9 bushels, while the best was 28.6 bushels. Such differences in yield emphasize the fact that choice of a variety is a matter in which the person not familiar with soybean types and varieties may easily make a costly error. It is reasonable to assume, however, that any farmer growing beans on fairly fertile soil, who chooses one of the better varieties and observes recommended cultural practices, should produce, on the average, 20 to 25 bushels of seed to the acre.

It will be noted from Table 1 that the ten-year average yield of beans—22 bushels—represents 42 percent of the corn yield—52 bushels—for the same period. These data are taken from the South-Central rotation of the University South Farm at Urbana and are the

TABLE 1.—COMPARISON FOR A TEN-YEAR PERIOD OF THE YIELDS OF CORN AND SOYBEANS ON THE STANDARD PLOTS IN THE SOUTH-CENTRAL ROTATION, UNIVERSITY SOUTH FARM, URBANA

(Bushels per acre)

	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	Aver.
Corn	66.0	48.6	54.0	42.3	51.1	45.6	53.9	55.4	51.2	51.9	52
Soybeans	17.7	16.1	20.1	19.0	32.1	19.3	13.4	16.6	32.2	32.7	22
Percent the soybean yield was of corn.	26.8	33.1	37.2	44.9	62.8	42.3	24.9	30.0	62.9	63.0	42

average yields secured on the standard plots for the first-, second-, and third-year crops of corn and the average for the same plots when producing soybeans.

The average November and December farm prices paid Illinois growers[25*] for their soybeans for the five-year period 1921-1925 were $1.48 and $1.90 a bushel respectively. Commercial beans have sold as low as 90 cents a bushel at harvest time and as high as $1.65 as the available seed became scarce. During each of the past three seasons (1925, 1926, 1927) soybean mills have paid the producer approximately $1.25 a bushel f.o.b. the mill. If the farmer is able to produce only 20 bushels of beans to the acre and sells them at average commercial bean prices, he is probably just about meeting costs of production, assuming a liberal allowance for the value of the roughage. On the other hand, if he markets a portion of his crop as seed at the average price received by farmers during the past five years for beans of seed quality, he will make a profit.

Adapted to Practically All Illinois Soils

The soybean has a wider adaptation than any of the other legumes commonly grown on Illinois farms. With the single exception of the cowpea, the soybean is more acid-resistant than any other legume now grown extensively as a field crop in this state. It is better adapted to the climatic conditions of northern and north-central Illinois than the cowpea. Like other crops, it attains its best development on the more fertile soils, altho in favorable seasons it yields well on the less productive lands.

Compare Favorably With Cowpeas on Poorer Soils.—Comparative yields of soybeans and cowpeas grown on two soil experiment fields typical of the relatively poor soil of the regions in which they are located are given in Table 2. They represent soil types to which the cowpea has generally been considered more nearly adapted than the soybean.

Altho these data are not sufficient to warrant a final statement, they indicate that the soybean crop compares favorably with the cowpea on both treated and untreated lands in the two cowpea-growing sections of the state where these two soil types are located.

Produce Best on Corn Soils.—Production figures for the experimental fields located on the dark-colored silt loam soils show small differences in favor of soil treatment. Fertilized plots on eleven fields, including 40 hay crops, gave an average yield only slightly above the untreated plots. Similar results were found for the seed production of 55 crops produced on seven fields.

Since results secured with the other crops grown on these fields indicate that the two problems of first importance are the supplying of limestone and nitrogen, it is not surprising that soil treatment has

had but little influence on the yields of well-inoculated soybeans, for the average lime requirement of the dark-colored silt loam soils is not sufficiently high to depress appreciably the growth of the soybean crop and a supply of available nitrogen is accessible thru the action of the nitrogen-fixing bacteria growing in the nodules on the roots of the plants. Investigations have shown that soybeans are more acid-resistant than red clover and for that reason they will grow better than clover on soils that are moderately acid. On such soils soybeans will

TABLE 2.—COMPARATIVE YIELDS OF COWPEAS AND SOYBEANS ON THE UNIVERSITY EXPERIMENT FIELDS AT UNIONVILLE AND OQUAWKA IN THE EXTREME SOUTHERN AND WESTERN PARTS OF ILLINOIS

Soil	Crop	Number of crops	Soil treatment		
			0	MLP	RLP
			tons	*tons*	*bu.*
Light-colored silt loam (Unionville)	Cowpea...	5	.57	1.18	4.9
	Soybean...	5	.43	1.39	6.0
Dune Sand (Oquawka)	Cowpea...	3	.74	.83	4.5
	Soybean...	3	.55	.77	4.2

The soil treatment in this and following tables is designated by the following symbols:

0 = None
R = Residues (residues from crops, and legumes used as green manure)
M = Manure
MP = Manure and rock phosphate
RP = Residues and rock phosphate
ML = Manure and limestone
RL = Residues and limestone
MLP = Manure, limestone, and rock phosphate
RLP = Residues, limestone, and rock phosphate
RLPK = Residues, limestone, rock phosphate, and potassium (usually in the form of kainit)

seldom show any response to applications of limestone, whereas red clover will be markedly improved. A comparison of the two crops is given in Table 3.

However, even tho the soybean is one of the acid-resistant legumes, it responds readily to an application of limestone when growing on distinctly sour soils. Light-colored soils, which in Illinois are generally more acid than dark soils, have shown marked improvement in the growing of the soybean after limestone applications were made. The influence of the limestone in increasing the general productive power of the soil may, of course, be an important reason why the beans do better on the limed plots, and in addition, as will be shown later, the limestone affects favorably the life of the bacteria which live in the nodules on the roots of the soybean.

A similar beneficial influence of limestone upon the yields of the soybean has been found on the dune sand soil on the Oquawka soil experiment field, as shown in Table 2.

It is of interest to note that on the treated land the relative difference between the light- and dark-colored soils of the state is practically the same when the yields of soybeans and red clover are compared. On dark-colored silt loam soils the yield of clover is 68 percent better than on light-colored soils, whereas the yield of soybeans is 70 percent better. While the yields of soybeans on the untreated light-colored soils of southern Illinois are low, yet they are no lower, comparatively, than the yields of other crops. It appears, therefore, that

TABLE 3.—COMPARATIVE RESPONSE OF RED CLOVER AND SOYBEANS TO SOIL TREATMENT ON DARK-COLORED SILT LOAM SOILS

(The figures are averages of 40 hay crops of soybeans and 83 hay crops of clover on 11 different fields: 1910-1922)

(Tons per acre)

Crop	Soil treatment			
	0	M	ML	MLP
Red clover	2.06	2.43	2.60	2.64
Soybean	1.64	1.74	1.80	1.84

this crop is as well adapted to the soil and the climate of the southern portion of the state as the other field crops commonly grown there, and with the possible exception of sweet clover, that the yields are as greatly improved by suitable soil treatment as are the yields of the other crops.

Has Merit as a Soil-Builder

One of the merits listed for the soybean is the fact that it is a legume and therefore may function as a soil-improvement crop. The fact should be kept in mind, however, that even inoculated soybeans will not increase the nitrogen content of the soil unless a portion of the crop is returned to the land. Inoculated legumes secure approximately one-third of their nitrogen from the soil[3*] and two-thirds from the air. If, therefore, the entire crop above ground is removed and less than one-third of the plant is contained in the roots, there will be a loss of nitrogen from the soil in addition to the mineral elements removed. In the case of the soybean approximately nine-tenths of the plant is found in the tops and one-tenth in the roots according to investigations made at the Ohio Experiment Station.[20*] The soybean cannot, therefore, be expected to be effective in increasing the nitrogen content of the soil if the entire crop is removed and none of it returned in the form either of animal manure or of green manure.

For this reason the soybean would not be expected to compare favorably with the clovers for the maintenance of soil nitrogen. Brown and Stallings[3*] at the Iowa Station have found that 66 percent of the mature red clover plant is contained in the tops. Thus the entire removal of the top growth would not reduce the nitrogen content of soil provided the plants were well inoculated. Field results are in accord with the conclusion that the soybean is not so valuable for soil improvement as red clover when the entire crop is removed.

In the South-Central rotation on the University farm at Urbana the effect of soybeans upon succeeding corn crops is shown in the four-year rotation of corn, corn, corn, and soybeans. The results are given in Table 4.

TABLE 4.—INFLUENCE OF SOYBEANS ON YIELD OF CORN IN A ROTATION OF CORN, CORN, CORN, AND SOYBEANS, SOUTH-CENTRAL ROTATION, UNIVERSITY SOUTH FARM, URBANA

(Bushels per acre)

Corn yields after soybeans	Number of crops	Soil treatment			
		R	M	RP	MP
First year	17	47.6	51.9	53.3	53.3
Second year	17	42.1	44.8	45.3	47.1
Third year	16	38.2	38.7	42.7	43.0
Increase of first-year corn over third-year corn	..	9.4	13.2	10.6	10.3

In this case the soybean crop apparently has a beneficial effect upon the succeeding corn crop. It is impossible to say whether this influence is due merely to a change of crops or to some other factor. It is interesting in this connection to note that the yield of corn on the Morrow plots, on the University North Farm, at Urbana, is 10 bushels an acre higher in the corn and oats rotation than where corn grows continuously. This is approximately the difference in yield between first-year corn after soybeans and third-year corn after soybeans.

Fits Well Into Illinois Rotations

The soybean crop fits into many rotations advantageously. It is suitable for either livestock or grain systems of farming but when used on the strictly grain farm, consideration should be given to the matter of maintaining the fertility of the soil with other legumes. The soybean should be given a place in the rotation more particularly because of its merit as a money crop—that is, for its value as a seed or hay crop—and any fertility value which might result should be re-

TABLE 5.—INFLUENCE OF SOIL TREATMENT ON YIELDS OF SOYBEAN HAY, UNIVERSITY EXPERIMENT FIELDS

(Tons per acre)

Kind of soil	Number of fields	Number of crops	Soil treatment			
			0	M	ML	MLP
Light-colored prairie[1]	5	31	.62	.71	.97	1.06
Light-colored timber[2]	3	22	.60	.75	1.07	1.22
Dark-colored prairie[3]	11	40	1.64	1.74	1.80	1.84
Sand[4]	1	8	.83	.95	1.23	1.22

[1]Soil experiment fields at Ewing, Newton, Oblong, Toledo, and Sparta.
[2]Enfield, Raleigh, and West Salem fields.
[3]Aledo, Carlinville, Carthage, Clayton, Dixon, Joliet, La Moille, Minonk, Mt. Morris, Sidell, and Pana fields.
[4]Oquawka field.

TABLE 6.—INFLUENCE OF SOIL TREATMENT ON YIELDS OF SOYBEAN SEED, UNIVERSITY EXPERIMENT FIELDS

(Bushels per acre)

Kind of soil	Number of fields	Number of crops	0	M	ML	MLP	0	R	RL	RLP	RLPK
Dark-colored prairie[1]	7	21	16.6	19.6	21.7	21.0	....	....	....	....	....
Dark-colored prairie[2]	8	55	....	....	....	....	14.7	14.4	16.7	17.1	17.3
Light-colored timber[3]	3	27	....	....	....	....	4.3	5.4	8.2	10.3	11.0
Light-colored prairie[4]	6	55	....	....	....	....	5.8	6.6	10.6	10.9	10.8
Sand[5]	1	12	8.8[6]	11.1[6]	14.8[6]	14.9[6]	6.1	6.4	9.7	9.8	9.7

[1]Fields at Aledo, Carlinville, Carthage, Clayton, Dixon, LaMoille, and Minonk.
[2]Aledo, Carlinville, Carthage, Clayton, Dixon, Joliet, LaMoille, and Minonk fields.
[3]Enfield, Raleigh, and West Salem fields.
[4]Ewing, Sparta, Newton, Oblong, Odin, and Toledo fields.
[5]Oquawka field.
[6]Four crops only.

garded as an additional gain. In other words, the soybean crop should not be used to replace other legumes in the rotation.

The following are a few suggested rotations which may be modified according to special circumstances. They are suggested merely to illustrate how soybeans may fit into a corn-belt rotation and do not take into consideration labor distribution. That is a problem for each farmer to decide, depending upon the acreages of the several crops which he is raising.

Five-year rotations

1. Corn, corn, soybeans, wheat, clover, or sweet-clover pasture
2. Corn, soybeans, wheat, clover, wheat (sweet-clover catch crop)

Four-year rotations

1. Corn, oats, soybeans, wheat (sweet-clover catch crop)
2. Corn, corn, soybeans, wheat (sweet-clover catch crop)

Three-year rotation

1. Corn, soybeans, wheat (sweet-clover catch crop)

The yields of soybean hay and seed obtained on twenty Illinois soil experiment fields over the state are found in Tables 5 and 6.

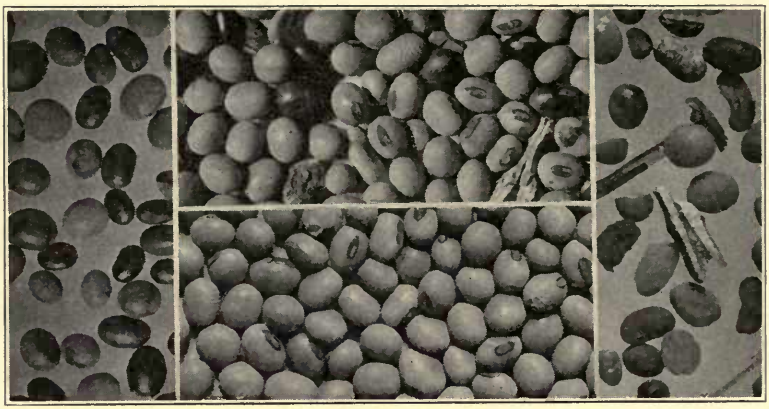

FIG. 2.—WELL-SELECTED SEED IS NECESSARY FOR GOOD RESULTS

Quality in soybean seed is more important than often is recognized. A chipped or cracked seed is unsafe, broken or split beans produce nothing, prevent a full seeding, and are a loss of good feed. Pure seed of one variety insures against variations in color and maturity. Upper center, typical low-grade seed; lower center, pure seed from the same sample; left end, impure seed (7 varieties) from sample; right end, trash, split, cracked, and rotted seed from sample.

ESSENTIAL CULTURAL PRACTICES

A Good Seed Bed

Successful soybean production is dependent upon the crop being started with a good seed bed. The bed must be firm and there must be enough loose soil to cover the seed well and sufficient moisture to sprout it promptly. The ideal seed bed is prepared either by fall or by early spring plowing followed by harrowing or light disking at frequent intervals during April and May.

It is desirable to kill as many weeds as possible before seeding. Stirring the ground thoroly just before the seeds are planted is important, as this will kill the crop of weeds just starting and thus give the soybean seed at least an even chance with the weed seeds which remain. Thoro and proper preparation of the seed bed will largely overcome the seriousness of the weed menace later in the season.

Disking as a substitute for plowing in the preparation of a seed bed for soybeans is seldom advisable, but there may be an occasional field in which the soil is mellow and the surface soil clean and relatively free of weeds, where a good seed bed can be prepared by disking. At the Ohio Station[20*] soybeans seeded at the rate of 3 pecks per

acre in 24-inch rows on disked corn stubble land yielded 10.58 bushels of seed and 1,895 pounds of straw as compared with 15.79 bushels of beans and 2,052 pounds of straw on plowed and prepared corn stubble land.

Thoro Inoculation

Thoro inoculation of the soybean is imperative if the crop, in addition to its many other desirable qualities, is to be useful for soil improvement. Being a legume the soybean is able to secure a large part of its nitrogen requirement from the air provided its roots are well supplied with nitrogen-gathering bacteria living within the nodules on the roots of the plants. Such plants are said to be inoculated. If not inoculated, the soybean must depend upon the soil for its nitrogen as well as for its mineral requirements. Therefore, in order to function as a "soil-building" crop, the soybean must be inoculated.

The value of inoculation is not limited, however, to its influence upon subsequent crop yields but an immediate benefit is obtained in the form of an increased yield of beans, and furthermore the bean crop itself contains a higher percentage of protein than the uninoculated crop. These facts are well brought out in the results secured in 1924 on the University Farm at Urbana and given in Table 7.

TABLE 7.—EFFECT OF INOCULATION ON COMPOSITION AND YIELD OF MANCHU SOYBEANS, UNIVERSITY FARM, URBANA, 1924

	Yields		Protein content			
	Hay	Seed	Hay		Seed	
	tons	*bu.*	*perct.*	*lbs. per ton*	*perct.*	*lbs. per ton*
Inoculated.....	2.53	46.6[1]	15.81	316.2	35.25	705
Not inoculated....	1.78	34.7[1]	14.62	292.4	31.05	621
Gain for inoculation	.75	11.9[1]	1.19	23.8	4.20	84

[1]The high yield of seed is due to the fact that the beans were harvested and threshed by hand; in this way there was practically no loss.

Altho a gain of 1,500 pounds of soybean hay and 11.9 bushels of beans per acre is not an unexpected increase, it should not be assumed that such gains may be obtained under all conditions. The response of this crop to inoculation will be influenced by the fertility of the soil, the less productive soils giving a higher percentage increase than the more fertile fields. On some of the best soils only small increases in the bean yield may be secured at times thru inoculation, whereas much larger returns may be secured on the poorer soils of the state. The protein content of the crop will be increased, however, by inoculation even tho there is no increase in yield, according to investigation at the Michigan Station.[23*]

Unlike the other common legumes, the bacteria from no other kind of crop have the ability to produce nodules consistently on the soybean. Altho some strains of cowpea nodule organisms infect the soybean, other strains fail. Furthermore some strains of cowpea bacteria are poor nitrogen-fixers when growing on the roots of the soy-

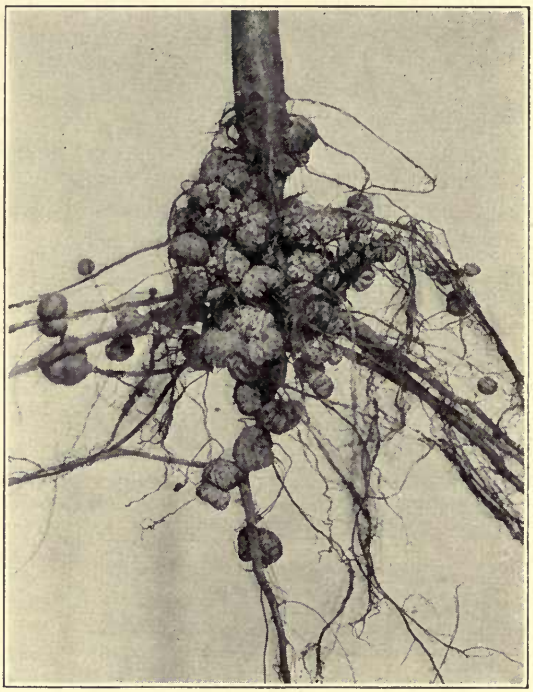

FIG. 3.—A THOROLY INOCULATED SOYBEAN PLANT

The nodules are numerous and of medium size, indicating that this plant was probably grown in soil where soybeans had been grown before. When inoculated beans are grown in a soil for the first time, the nodules will usually be large but few.

bean. It is therefore important that the soybean be artificially inoculated the first time or two that the crop appears upon the land. After the land is once supplied with suitable bacteria, the necessity for further inoculation of the seed will depend upon the frequency with which the crop appears in the field and also upon the acidity of the soil. Even on soils which are only moderately sour, the application of lime tends to prolong the life of these organisms. This fact is illustrated by data secured from the University Farm at Urbana. The South-Central rotation consists of corn, corn, corn, and soybeans. In

this system of cropping, with the soybeans appearing every fourth year, the number of nodules is considerably higher on the limed plots than on the unlimed. Inoculated soybeans having been grown on these plots several times, the seed that was used in 1925 was not inoculated. Plants from these plots were carefully dug and the number of nodules counted. The results secured indicate (Table 8) that

TABLE 8.—NUMBER OF NODULES ON TWO VARIETIES OF SOYBEANS GROWN ON LIMED AND UNLIMED PLOTS, UNIVERSITY SOUTH FARM, URBANA, 1925

Variety	Average number of nodules per plant	
	Limed plots	Unlimed plots
Ebony.....	50.00	29.45
Manchu.....	43.85	29.03

soils which are in a low state of fertility and especially those which are distinctly acid will require special attention as to inoculation. It may even be necessary under some circumstances to inoculate anew at every seeding of soybeans.

Inoculation by Direct Transfer of Soil.—Methods practiced in inoculating have changed during the past few years. Formerly, bacteria were carried from one field to another thru a direct transfer of soil. The practice was to spread 400 to 600 pounds of inoculated soil upon each acre of the field in which inoculation was desired. This was an effective method but objections to it were the cost of hauling such large quantities of soil and the possibility of scattering weed seed and spreading plant diseases.

"Muddy-Water" Method of Inoculation.—More recently a modification of this soil method has been used and is known as the "muddy-water" method. The procedure is as follows:

> To a measured quantity of well-inoculated soil add an equal amount of water. Stir this for approximately five minutes in order to break up all the lumps of soil and to permit the bacteria to be washed into the muddy water. After the soil has settled for another five minutes, remove the trash from the surface of the liquid. Sprinkle approximately one pint of this muddy water over each bushel of seed, making sure that the seed is stirred until every one is moistened. They may then be spread out and allowed to dry in the shade.

The inoculation of soybeans requires care, especially as regards the amount of water applied, for excess water will loosen the seed coats, causing them to "slip" in handling. Drying may be hastened by sprinkling some of the dry, inoculated soil on the seeds and stirring them again. Seeding should follow the inoculation operation as soon as convenient.

Soil for inoculating purposes should be secured from a field in which the soil is sweet and in which the soybeans showed abundant nodule development. In order to insure as thoro inoculation as possible, soil should be taken from around the roots of well-inoculated plants.

FIG. 4.—INOCULATING SOYBEANS BY THE "MUDDY-WATER" METHOD

Well-inoculated soil must be used and every seed moistened with the muddy water. At the same time it is very important that an excess of water be avoided, for it injures the beans by causing the seed coats to "slip" and the result is a poor stand.

Commercial Inoculants.—Comparatively recently it has been found possible to grow legume bacteria in the laboratory and then transfer these organisms to the proper legume seed very successfully. The development of this method has now reached the stage where nodule bacteria may be secured from a large number of commercial laboratories at a cost ranging from 25 cents to one dollar for each bushel of seed to be inoculated. Many of these cultures are not only less difficult to handle, but apparently in the hands of some farmers they give more satisfactory results on soybeans than do the soil methods.

Seed Soon After Corn Planting

Under Illinois conditions the proper time to seed soybeans is about the time corn is planted. With most varieties late planting should be avoided, especially if the crop is to be grown for seed, since practically all common varieties require the entire season to mature.

Early planting will usually be accompanied by somewhat earlier ripening, altho the difference in time of maturity will not be so great as the difference in time of planting. The soil temperature requirement for germinating the soybean is about the same as that for corn. The chief reason for seeding soybeans a few days after corn is planted is to enable the grower to kill another crop of weeds.

Two Common Methods of Seeding.—Soybeans are commonly planted in rows to permit of cultivation, and they are also drilled as for small grain. A grain drill, a corn planter, or a sugar-beet drill may be used. The grain drill enables the farmer either to seed the beans solid, in the same manner as wheat or oats, or to space them in rows of any desired width. The corn planter and the sugar-beet drill seed only in relatively wide rows. Most corn planters are adjustable, and with some kinds it is possible to seed in rows as narrow as 30 inches. Sugar-beet drills are adjustable, the rows varying from 15 to 30 inches. With the coming of the combine some objection has been found to soybeans grown in rows because of the tendency to ridge the land during cultivation. When soybeans are grown in rows and cultivated, care should be exercised to keep the surface soil level if a combine is to be used in harvesting.

The method of seeding did not appear to influence markedly the yields of seed from the Ebony variety on the University South Farm at Urbana during the three years 1913-1915, as may be noted from Table 9. The yields of straw show a somewhat greater fluctuation in 1915, when the 7-inch and broadcast plots were included.

Whether the crop is to be grown for hay or for seed will influence somewhat the method of seeding. The crop can be grown satisfactorily when seeded solid with the grain drill if the land has been carefully prepared and if the presence of some weed grasses in the crop at harvest time is not objectionable. Planting in rows 18 to 32 inches apart, depending upon the machinery available, is preferable if the

TABLE 9.—EFFECT OF SPACE BETWEEN ROWS ON YIELDS OF SOYBEAN HAY AND SEED CROPS, UNIVERSITY SOUTH FARM, URBANA

Space between rows	Yield of straw				Yield of seed			
	1913	1914	1915	Aver.	1913	1914	1915	Aver.
inches	*tons*	*tons*	*tons*	*tons*	*bu.*	*bu.*	*bu.*	*bu.*
7	....	....	1.44	1.44[1]	....	....	25.4	25.4[1]
14	.66	1.26	1.26	1.06	16.1	26.6	23.4	22.0
21	.78	1.32	1.12	1.07	21.1	25.1	26.0	24.0
28	.63	1.15	1.05	.94	18.3	25.3	25.4	23.0
35	.72	1.10	.88	.90	18.6	25.6	23.8	22.6
40	....	....	.70	.70[1]	....	....	19.5	19.5[1]
Broadcast	....	....	1.43	1.43[1]	....	....	26.5	26.5[1]

[1]One year only.

FIG. 5.—DRILLING SOYBEANS IN A WELL-PREPARED SEED BED

In preparing the seed bed for soybeans, it should be the aim to kill as many weed crops as possible. Some good weed-killing implement should precede the drill preferably by two to four hours.

FIG. 6.—DRILLING FOUR ROWS OF SOYBEANS AT A TIME

Machinery designed for seeding beets and beans is well adapted for soybeans. This drill will seed soybeans in 20-, 22-, and 24-inch rows and at rates varying from 30 to 100 pounds to an acre depending upon the width of the row and the size of the seed.

grower expects to keep out weeds or if he desires to use a minimum amount of seed in planting. Soybeans planted in rows at the usual rates will produce seed that is larger, plumper, and of finer quality than beans that have been drilled solid or grown in rows in which the seed is planted very thickly.

The Ohio Experiment Station[24*] reports a test comparing soybeans planted solid with those grown in rows. This test included two varieties and covered a period of two years. The greatest total yield was produced where the beans were grown in 24-inch rows.

Rate of Seeding Varies With Conditions.—The rate of seeding depends upon four considerations: the variety or size of seed, the method of seeding, the vitality of the seed used, and the use to be made of the crop.

The size of seed varies with different varieties. The larger-seeded varieties, such as Mammoth Yellow, Tarheel, Elton, Hamilton, Black Eyebrow, and Haberlandt, have from 125 to 200 seeds to an ounce. Medium-sized seed from varieties such as A. K., Ebony, and Midwest (Mongol or Hollybrook) run from 200 to 300 an ounce, while small-seeded varieties, such as Peking (Sable), Wilson V, Lexington, and Arlington have from 300 to as many as 400 seeds to an ounce. This wide variation necessitates some consideration when seeding. The following suggested rates are based upon medium-sized seed, such as that of Midwest (Mongol or Hollybrook). Rates for larger or smaller seeds may be proportionately increased or decreased as occasion demands. It should be remembered that inoculated beans seed more slowly than uninoculated beans, and an allowance of 10 to 20 percent should be made when they are being seeded.

Seeding in rows 28 to 32 inches apart requires 35 to 45 pounds of seed to the acre, depending upon the size of seed. Seeding solid with the grain drill requires from 6 to 7 pecks. Seeding in corn, either for hogging-off or for silage, is usually done at the rate of 1½ to 2 soybean seeds to a kernel of corn. This will require, of the medium-sized seed, approximately 2½ to 3½ pounds of seed to the acre, thus making one bushel of seed sufficient for about 17 to 25 acres.

Give Careful Attention to Cultivation

Proper cultivation in the production of soybeans cannot be overemphasized. Most effective cultivation will usually be done before the beans are planted. It is frequently advisable and sometimes necessary to cultivate beans once before they come thru the ground. If weeds get started more rapidly than the beans, a thoro harrowing or cultivating before the plants are up will be of great help.

In soils which tend to crust badly it is advisable to break up the hard surface two or three days before the beans are ready to come

FIG. 7.—A ROTARY HOE BREAKING THE CRUST THAT FORMS AFTER RAINS

If used in time, this implement will usually help the seedlings to come thru the ground. While some are undoubtedly destroyed by the hoe, fewer are sacrificed than if left to break their own way thru the crust.

FIG. 8.—THE ROTARY HOE IS ALSO WIDELY USED IN CULTIVATING DRILLED SOYBEANS

This implement, if used when weeds and weed grasses are just starting, and used frequently, will keep the crop clean until bloom starts, when it is advisable to stop all cultivation.

thru. Plants are easily broken off just as they are coming thru the ground and frequently, unless given assistance, will "break their necks." This is the most critical of the cultivation processes and must be done just as soon as possible after the crust forms. The rotary hoe works admirably for this purpose, the spike-tooth harrow is satisfactory, or the weeder may be used provided it will break the crust.

Beans seeded in rows are commonly cultivated with corn machinery; the ordinary two-horse corn cultivator is the most commonly

FIG. 9.—ANOTHER TOOL FOR CULTIVATING SOYBEANS

The harrow may be used effectively provided the work is done frequently enough to kill each crop of weeds while in the seedling stage. A light harrow can be used until the beans are 6 to 8 inches high.

used and probably the most satisfactory implement generally available for this purpose. Beans seeded solid are as a rule cultivated with the rotary hoe, an excellent implement for the purpose. At the Iowa Experiment Station,[10*] in a comparison of the rotary hoe, harrow, and weeder as implements for the cultivation of beans, it was found that the rotary hoe killed the fewest beans. The investigators did report, however, that if weeds were allowed to get started, "the harrow and weeder were more effective in killing the weeds."

Cultivation should be frequent enough to keep down weeds, at least until the beans are tall enough to shade the ground. As a rule, beans in rows can be cultivated until they are practically ready to bloom, by which time they will be large enough to make considerable

FIG. 10.—CULTIVATING SOYBEANS WITH A WEEDER

The weeder is a good implement for cultivating soybeans provided the soil is loose and mellow. In compact or crusted soil it may not stir the soil deeply enough to kill the weeds.

FIG. 11.—BEET AND BEAN CULTIVATOR USED FOR SOYBEANS

This implement is designed to be used when the crop has been seeded with the drill shown in Fig. 6.

shade and thus more nearly control the weeds. Two or three cultivations after the beans are up will usually be sufficient.

HARVESTING AND THRESHING SOYBEANS

Harvesting the Hay Crop

Soybeans make good hay any time after the pods form and until the leaves begin to fall. Early-cut hay is probably richer in protein,[24*] but hay cut after the seeds are well formed and before the leaves fall gives the greatest total yield. Palatability, and therefore the proportion of the hay consumed by stock, seems to decrease as maturity approaches.

Soybean hay is much more readily cured than cowpea hay. Rains which would ruin a crop of cowpea hay will apparently do little more harm than to discolor soybeans. Discolored soybean hay is probably not so nutritious as that made without exposure to rain, but it is nevertheless of good feeding value and stock do not seem to object to it. The average yield of hay on the South-Central rotation on the University South Farm for the twenty-two varieties, a total of 97 hay crops, tested during the last eight years (1919-1926) is 2.20 tons per acre. The highest yielding variety for the four-year period (1919-1922) during which it was grown was Peking with an average yield of 2.56 tons (Table 21). The average yield of medium-maturing soybeans on fertile soils may be expected to be two to three tons of hay per acre. On the less fertile soils beans of a hay type, such as Virginia, Wilson V, Ilsoy, Lexington, and Morse, should yield from 1.75 to 2.5 tons.

The mower is the implement most commonly used for cutting the hay crop. The binder, favored by some growers, has some disadvantages. Soybeans cut at the proper stage for good hay contain a large percentage of water. If bound tightly at this stage there is almost certain to be some loss from molding. When cut with a mower, soybeans are usually allowed to remain in the swath for about a day in order that they may become thoroly wilted. After wilting, the crop is raked into windrows and allowed to complete the curing. After one day in the windrow the hay is sometimes put into shocks or bunches to cure out thoroly. A good quality of hay, however, can be made direct from the windrow.

Harvesting for Seed

The soybean seed crop should be cut when the pods are fully matured, the seed in the hard-dough stage and, with most varieties, when the leaves are practically all off. If cut earlier, the seed will usually wrinkle badly during the drying period, will appear inferior, and will be difficult to keep from molding, especially if put into bins. Inexperienced growers sometimes attempt to harvest the seed crop early before the leaves fall, thinking that by so doing they can get a much better quality of straw, a quality more nearly approaching hay.

There is no one time, however, when soybeans can be cut and produce a crop of good hay and at the same time make a good seed crop. A hay crop will usually be cut three weeks or a month before the seed crop is ready to harvest.

The grain binder is generally used for harvesting the seed crop, but some varieties, especially when grown on poor soils, grow so short that it is necessary to use the mower in order to save the crop. The self-rake reaper and the clover buncher are good machines for cutting short beans. When cut with a binder, soybeans are handled in practically the same manner as any other grain. The bundles should be comparatively small and not bound too tightly, especially when the beans are cut relatively early before the leaves are all off and the plants thoroly dried. Bundles should be set up in small shocks and allowed to cure in the field.

Soybeans frequently lodge badly on rich land. This is especially true of tall, slender, vining types, such as Wilson and Virginia. Harvesting beans which have lodged is a difficult task. The ordinary binder equipped with the extra guards, or "fingers," made for picking up lodged grain works fairly satisfactorily but will not completely gather the crop.

Where threshing equipment is not likely to be available for a considerable time after harvest, it may be advisable to stack the beans. After curing in the field, the soybean bundles can be stacked with excellent success. Stacking soybeans is done in much the same manner as stacking wheat. This method of handling is especially desirable when the time of threshing is indefinite or where it is necessary to fall-plow or to seed another crop in the soybean field before threshing can be done.

Threshing the Seed Crop

Many growers, after producing a good crop of soybeans and harvesting them efficiently, have had difficulty in getting the crop threshed.

The ordinary grain separator should thresh soybeans satisfactorily after a few adjustments are made. The speed of the cylinder must be reduced to approximately one-half the normal threshing rate. Threshing machines[1*] have an optimum speed at which the manufacturer advises they be run. In threshing soybeans a speed of two-fifths to one-half the indicated revolutions per minute will in most cases be satisfactory when the beans are dry. The first concave should always be removed and a wood blank substituted. This will materially reduce the percentage of chipped and broken beans. When threshing beans that are damp, it may be necessary to use all the concaves in order to get all the seed but even then most of the teeth should be removed, leaving perhaps one-third to one-half the usual number. If necessary to use the concave it should be lowered, setting it far enough away from the cylinder to reduce the cracking of the beans to a minimum.

In threshing dry beans, the wood blank and the reduced cylinder speed should shell out all the seed and practically do away with the splitting of the beans.

Reducing the speed of the cylinder will slow down the remainder of the separator correspondingly so that the machine will not clean the grain and elevate the straw effectively. To overcome this a large pulley should be put on the cylinder shaft and the speed of the remainder of the machine thus kept at least at its normal rate.

Special Machines for Harvesting and Threshing

There are several special pea and bean hullers on the market which thresh soybeans satisfactorily. Some of these machines are

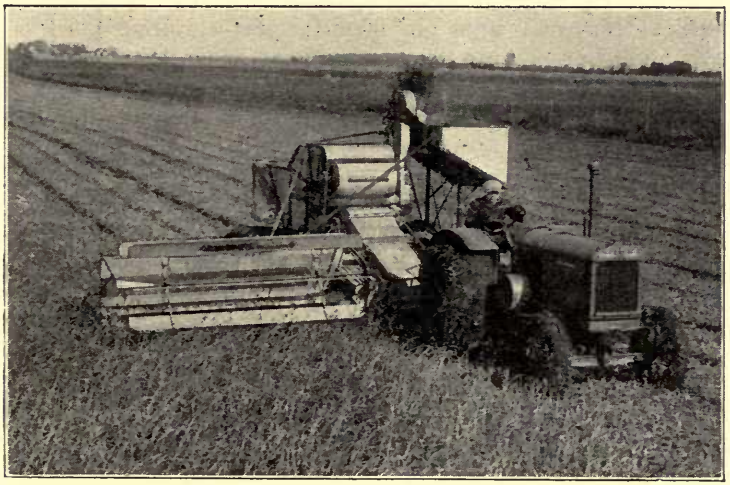

FIG. 12.—HARVESTING A GOOD CROP OF MANCHUS WITH THE COMBINE

The ground is quite soft and yet the beans are dry enough for threshing. Combines are gaining in popularity and are very effective when properly adjusted and in charge of a careful operator.

designed primarily for cowpeas, others for navy beans, but all of them when properly adjusted will thresh soybeans.

Several harvesters or strippers designed to gather beans grown in rows have been developed in the Carolinas and Virginia. These machines strip the beans and pods from the standing stalks, depositing the harvested material in large hoppers. The beans, pods, and trash are later run over cleaning equipment to separate the clean seed. These harvesters have not been widely used in Illinois. They have some promise for the grower who produces only a small acreage for seed and is interested in utilizing the straw for soil improvement only. In

order to operate them successfully, rather tall, erect-growing varieties must be chosen. The shorter varieties which produce their pods low on the stalk cannot be completely gathered. Neither can the tall, slender, vining types be satisfactorily handled by this mechanical picker. These machines have been improved greatly during the past few years and no doubt further improvements will be made.

Soybean harvesting and threshing methods have been very unsatisfactory for the grower who harvests 50 to 200 acres or more of seed beans each year. During the past four years, as the result of an increasing call from the soybean producers for improved seed harvesters and threshers, the machinery manufacturers are now offering several field threshers of the same type as those used in the wheat fields of the West. The combine was first used in Illinois as a soybean thresher in 1924.[14*] Twelve machines were reported in operation in Illinois in 1925, 64 in 1926, and with five manufacturers offering machines in 1927 the number available during October and November, 1927, exceeded 300.

The combines all work on the same general principle,—that of cutting the mature plants and elevating them to the cylinder, where the beans are threshed out. The hulled beans are then passed over screens and thru the blast of a fan just as in the ordinary thresher. The clean seed is then elevated and either conveyed to a seed bin which is carried on the machine, run directly into a wagon which is drawn along the side of the combine, or run into sacks which are tied and dropped off the machine. The straw, pods, leaves, and trash are carried to the rear of the thresher, where they may be scattered over the land by means of a beater or straw spreader or may be bunched to facilitate their collection in case the farmer wishes to feed the straw.

The combines when properly adjusted and in charge of a careful operator will gather a greater percentage of seed than any other harvesting machine, according to observations made by the Farm Mechanics Department of the University of Illinois.

The advent of the combine marks a new epoch in soybean production. There are several points in favor of these machines which bespeak an increasing interest in them, namely:

1. They do the work with a single operation and therefore reduce harvesting costs.
2. They shorten the harvesting season, thus enabling the grower to take full advantage of favorable weather.
3. When properly adjusted they enable the farmer to harvest the crop with less loss than by other methods.
4. They leave the residues in the field where produced.
5. Standing beans are not injured by inclement weather, as are beans that are cut and shocked awaiting the thresher.
6. Mature soybeans harvested with a combine will usually have a lower moisture content than the average lot that is cut, shocked, and threshed, especially if rains are frequent.

On the other hand, there are objections which must necessarily be weighed before one comes to a decision as to the most satisfactory method of handling the soybean seed crop, namely:

1. Late harvesting is likely to endanger, if not prevent, the seeding of winter wheat in the soybean stubble.
2. Combines are costly.
3. There is danger of losing straw which might otherwise be used as winter roughage.

Handling Threshed Soybeans

The method of handling soybean seed immediately after threshing is important. Improper handling has caused the loss of thousands of bushels of good seed. It is not safe to store soybeans having a high moisture content in a deep bin. Soybeans which test more than 12 percent moisture at threshing time should be examined frequently if stored in large lots. When the moisture content exceeds 15 percent, they should either be spread out to permit frequent stirring or else be put in bags which can be moved about. Where only small lots are handled, the threshed beans are sometimes put into loosely woven burlap sacks, about 1½ bushels of seed to a sack. These sacks are then set in rows and space left between the rows. If the beans begin to heat, they can be stirred by inverting the sacks, and in this way loss will usually be avoided. Soybeans stored in sacks set up in rows have ample circulation of air for drying. Seed stored in sacks and corded up is susceptible to heat damage if the moisture content is high.

SOYBEANS AND CORN AS COMPANION CROPS

The rapid increase in the acreage of soybeans for hay and seed production has stimulated interest in the crop for other purposes. The fact that soybean hay proved a valuable high-protein roughage led farmers to consider the production and utilization of the seed as a substitute for the commercial concentrates. Since these concentrates appeared to be essential for economical pork production, the practice of seeding soybeans with corn, to be pastured or hogged-off, introduced the problems of crop competition with a new crop.

The Department of Agronomy of this Station began investigations in 1915 to ascertain the effect of this companion cropping on the yields of the respective crops. In order to ascertain the best method of planting, as well as to study the value of the mixture, corn and soybeans were seeded in two different ways—checked and drilled. In the check-rowed plots the corn was grown two stalks to the hill. Soybeans were seeded somewhat thicker, to a stand of approximately 1.5 soybean plants to one corn plant, or in other words, three beans to a hill. No thinning was done.

TABLE 10.—YIELD OF CORN IN CORN AND SOYBEAN COMPANION CROP EXPERIMENT, UNIVERSITY FARM, URBANA
(Bushels per acre)

Variety	Method of planting	1915	1916	1917	1918	1919	1920	6-year average	4-year average
Corn only	Checked	46.0	24.6	45.5	59.9	56.1	66.8	49.8	57.0
Corn and Ebony	"	42.6	18.4	43.7	53.1	47.1	58.1	43.8	50.5
Corn and Hong Kong	"	44.2	16.8	42.6	52.1	46.1	56.2	43.0	49.2
Corn and cowpeas	"	43.1	....	....	....	....	....	....	....
Corn and Medium Early Yellow[1]	"	....	....	47.2	56.2	53.0	59.7	....	54.0
Corn only	Drilled	54.8	21.0	44.3	48.9	58.9	59.1	47.8	52.8
Corn and Ebony	"	52.6	16.8	39.2	40.4	49.2	47.4	40.9	56.4
Corn and Hong Kong	"	50.6	14.4	37.3	49.7	47.9	50.1	41.7	46.2
Corn and Medium Early Yellow[1]	"	....	....	46.4	39.1	55.8	51.8	....	48.3
Corn and cowpeas	"	52.5	....	....	....	....	....	....	....

[1]Ito San.

In the drilled plots the corn was spaced approximately 14 inches apart, the beans approximately 10 to 12 inches, in an attempt to maintain the same relative proportion of corn and soybean plants as in the check-rowed plots.

In addition to studying the general effect of soybeans upon corn when grown as a companion crop, it seemed desirable to study the effect of different varieties of soybeans on a standard corn-belt variety of corn, Reid Yellow Dent. Three varieties of soybeans were used in the trials: Ebony, a medium-maturing hay type of bean; Hong Kong, a medium-late, rather large-growing, general-purpose bean; and Ito San, a typical early maturing seed type of bean. The different varieties were sown at approximately the same rate.

Table 10 summarizes the yields of corn in this experiment for the six-year period 1915-1920. It will be noted that Ito San did not appear in the trials until 1917. Consequently two separate averages are included; the one for the entire six-year period includes only the two varieties, Ebony and Hong Kong, the other, covering the four-year period, includes all three varieties.

After three years of this experiment it was thought advisable to ascertain the exact yields of the different varieties of soybeans when grown in the corn under both the checked and the drilled systems of planting. In harvesting the 1918 and 1919 crops comparative yields were therefore ascertained on representative plots. It is clear from Table 10 that the early maturing Ito San had the least depressing effect upon the yield of corn.

This yield is probably explained in part by the fact that it matured its seed crop sufficiently early to have relatively little competitive effect upon the corn and perhaps also in part by the fact that it had a poor stand. The average yield of Ito San for the two years, as indicated in Table 11, was 2.8 bushels an acre, with a loss in corn of only 3.4 bushels. The later varieties, it will be noted, produced considerably more soybeans, with a correspondingly greater reduction in corn. In the checked rows of Ebony, where 7.1 bushels of beans were produced, the loss of corn amounted to 7.9 bushels; while in the drilled plots, where 8.1 bushels of beans were produced, an even greater loss of corn, 9.1 bushels an acre, occurred. The Hong Kong soybean in the checked plots produced 6.2 bushels of beans, with a corresponding reduction of 8.9 bushels of corn, and in the drilled plantings the losses were even greater.

The average percentage of loss of all varieties for the four-year period referred to in Table 10 is 10.17 percent in the checked plots and 4.73 percent in the drilled plots. While these data, covering only four years of work (1917-1920), cannot be considered final, they do suggest that the differences in the relative competition of the different varieties may offer a solution to the problem of reducing losses that

TABLE 11.—YIELD OF CORN AND OF SOYBEANS IN CORN AND SOYBEAN COMPANION CROP EXPERIMENT, UNIVERSITY FARM, URBANA

(Bushels per acre)

Variety	Method of planting	Crop of 1918			Crop of 1919			Average of 1918 and 1919		
		Yield of corn	Loss of corn	Yield of beans	Yield of corn	Loss of corn	Yield of beans	Yield of corn	Loss of corn	Yield of beans
Corn only	Checked	59.9	....	....	56.1	....	....	58.0	...	...
Corn and Medium Early Yellow[1]	"	56.2	3.7	3.7	53.0	3.1	1.8	54.6	3.4	2.8
Corn and Ebony	"	53.1	6.8	5.3	47.1	9.0	8.8	50.1	7.9	7.1
Corn and Hong Kong	"	52.1	7.8	3.1	46.1	10.0	9.2	49.1	8.9	6.2
Average	....	....	...	...	....	....	....	51.3	6.7	5.4
Corn only	Drilled	48.9	...	...	59.0	....	....	53.9	...	...
Corn and Medium Early Yellow[1]	"	39.1	9.8	3.8	55.8	3.2	3.3	47.5	6.5	3.6
Corn and Ebony	"	40.4	8.5	3.6	49.2	9.8	12.5	44.8	9.1	8.1
Corn and Hong Kong	"	49.7	.8	3.3	47.9	11.1	11.0	48.8	5.1	7.2
Average	....	....	...	...	....	....	....	47.0	6.9	6.3

[1]Ito San.

result when these two crops are grown together. Farmers who have had experience growing the two crops in combination have observed a reduction in corn yield but seem to feel that the practice is nevertheless a good one. The fact that soybeans have a much higher protein content than corn has convinced some farmers that they can well afford to lose a small percentage of the corn for the corresponding gain in the richer protein concentrate.

The feeder may therefore be interested in seeing the production figures appearing in Tables 10 and 11 interpreted in terms of total digestible nutrients, crude protein, and protein produced per acre. This information is given in Table 12. The amounts of total digestible nutrients and of digestible crude protein were secured by applying to

TABLE 12.—TOTAL DIGESTIBLE NUTRIENTS, DIGESTIBLE CRUDE PROTEIN, AND NET PROTEIN PRODUCED PER ACRE BY CORN AND SOYBEANS AS COMPANION CROPS, UNIVERSITY FARM, URBANA

(Pounds per acre)

Feed	Production per acre	Digestible nutrients per acre			Crude protein per acre		Net protein	Total net protein
		Corn	Soybeans	Total	Corn	Soybeans		
Corn alone	3 133.2	2 685.2	.....	2 685.2	235.0	.....	136.3	136.3
Corn	2 657.2	2 277.2	.....	.....	199.3	.....	115.6	
Ebony soybeans	456.0	.....	429.1	2 706.3	.....	151.4	96.9	212.5
Corn	2 741.2	2 349.2	.....	.....	205.6	.....	119.2	
Hong Kong soybeans	402.0	.....	378.3	2 727.5	.....	133.5	85.4	204.6
Corn	2 858.8	2 450.0	.....	.....	214.4	.....	124.4	
Ito San soybeans	192.0	.....	180.7	2 630.7	.....	63.7	40.8	165.2

the production figures the analyses given by Henry and Morrison.[10*] The net protein was determined by applying the biological values[a] determined by Mitchell and Villegas[17*] to the figures for digestible crude protein.

It will be noted that the total digestible nutrients per acre are not materially influenced by the introduction of soybeans into the corn. The increase in crude protein produced per acre by the combination crop, however, is more marked, as shown by the fact that the addition of Ebony soybeans resulted in a gain of 118.36 pounds, Hong Kong 107.13 pounds, and Ito San 70.08 pounds, when compared with a plot of corn grown alone. In further studies of the biological value of proteins in animal feeding Mitchell and Villegas[17*] found that the proteins of the combination ration of corn and soybeans was slightly superior to either of the proteins when fed alone.

[a]The net protein of a ration is determined by multiplying the digestible crude protein by the biological value of that protein. The biological value of a protein is presumed to indicate what percentage of the digestible crude protein consumed by the animal may be retained for maintenance and growth.

SOYBEAN VARIETY STUDIES IN ILLINOIS

The regular variety trials of soybeans were begun at the University of Illinois in 1906 by comparing the seed production of seven varieties two of which had little or no value under Illinois conditions. The list has been extended from time to time until by 1926 a total of about fifty different kinds had been grown for more than one year. Numerous varieties and strains which proved worthless are not reported in this publication.

Results reported herein were obtained on the University South Farm at Urbana and on the northern Illinois crop experiment field at DeKalb. For the most part soybean variety trials at Urbana have been conducted in the South-Central rotation—a four-year rotation consisting of corn, corn, corn, and soybeans. The soil was limed in 1903 at the rate of ½ ton an acre. Rock phosphate has been applied every four years at the rate of 1 ton an acre. A section of plots has been operated under a grain system of farming where crop residues have been returned, while on a corresponding group of plots representing a livestock system farm manure has been applied.

TABLE 13.—DEKALB FIELD: SOYBEAN SEED PRODUCTION
Annual yields of the different varieties and their percentage ratings using Ito San as the standard for comparison
(Bushels per acre)

Variety	1919	1921	1923	1924	1925	1926	Percentage rating
Midwest	....	30.9	....	....	....	....	152.2
AK2	....	....	....	....	34.0	....	127.8
Illini	....	....	....	....	33.6	18.6	126.7
Manchu	....	25.8	....	....	29.5	18.8	120.5
Dunfield	....	....	....	....	....	15.2	103.4
Chestnut	20.4	28.6	5.92	....	....	....	103.2
AK	17.0	....	16.8	....	....	....	102.7
Ebony	16.2	25.8	11.6	....	....	....	100.8
Elton	....	....	....	....	....	14.8	100.7
Black Eyebrow	....	23.9	14.0	....	25.6	....	100.6
Ito San (Medium Early Yellow)	16.7	20.3	16.2	....	26.6	14.7	100.0
Sherwood	15.2	....	....	....	....	....	91.0
Nuttal[1]	15.0	....	....	....	....	....	89.8
Wisconsin Black	....	24.0	9.3	....	23.1	....	89.5
Wilson	13.7	....	....	....	....	....	82.0
Mandarin	....	....	13.3	....	21.6	....	81.5

[1]This variety no longer being commercially available is omitted from the variety descriptions.

More recently variety trials have been made in the Northwest rotation which consists of potatoes, corn, soybeans, and alfalfa, the alfalfa remaining six years on the same series while the other crops rotate twice. The soil treatment on this rotation is the same as that indicated for the South-Central rotation except that heavy applications of rotted farm manure have been made every three years and that there are no grain-system plots; furthermore, limestone is applied in this rotation approximately every four years. The soil in this field would be regarded as very productive.

In all variety trials reported the crop was planted in rows 28 inches apart. The seed was inoculated each year until the crop had appeared on all fields in each rotation at least twice. The seeding has been done each year as soon as corn planting was completed. This means that the average date for these soybean seedings has been about June 1.

Performance of Varieties in Northern Illinois

Soybeans did not appear regularly in the rotation on the northern Illinois experiment field at DeKalb until 1926. The yields reported

TABLE 14.—DEKALB FIELD: SOYBEAN SEED PRODUCTION
Comparable average yields of the different varieties using Ito San as the standard for comparison
(Bushels per acre)

Variety	Number of years compared	Years on which comparison is based	Average yield
Ito San	5	1919, 1921, 1923, 1925, 1926.	18.9
Ito San	3	1919, 1921, 1923	17.7
Chestnut	3	1919, 1921, 1923	18.3
Ebony	3	1919, 1921, 1923	17.9
Ito San	3	1921, 1923, 1925	21.0
Black Eyebrow	3	1921, 1923, 1925	21.2
Wisconsin Black	3	1921, 1923, 1925	18.8
Ito San	3	1921, 1925, 1926	20.5
Manchu	3	1921, 1925, 1926	24.7
Ito San	2	1919, 1923	16.5
AK	2	1919, 1923	16.9
Ito San	2	1923, 1925	21.4
Mandarin	2	1923, 1925	17.5
Ito San	2	1925, 1926	20.6
Illini	2	1925, 1926	26.1
Ito San	1	1925	26.6
AK2	1	1925	34.0
Ito San	1	1921	20.3
Midwest	1	1921	30.9
Ito San	1	1919	16.7
Nuttal	1	1919	15.0
Sherwood	1	1919	15.2
Wilson	1	1919	13.7
Ito San	1	1926	14.7
Dunfield	1	1926	15.2
Elton	1	1926	14.8

in Table 13 were secured, therefore, at irregular intervals, soybeans having been seeded only in years when the alsike clover failed.

The greatest difficulty in growing this crop at DeKalb has arisen from the fact that in most years frosts damaged some or all of the varieties. During the seasons of 1925 and 1926 attempts were made to get good seed of the earlier maturing strains.

Seed Production.—Ito San, a commonly grown, early maturing, yellow-seeded bean, is one of the dependable varieties for northern

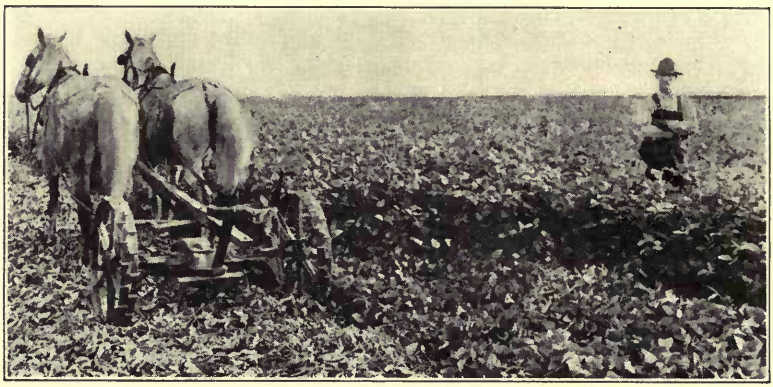

FIG. 13.—TWO AND A HALF TONS OF EXCELLENT HAY

Note the dense growth. Thick planting helps control weeds and tends to make a finer quality of hay.

Illinois. It is used as the standard since it has been grown thruout the period of these tests and is a consistent performer, having yielded a yearly average of 18.9 bushels an acre. As the standard it is given a percentage rating of 100 in the arrangement of results shown in Tables 13 and 14.

Black Eyebrow has been grown for three years. It is an early maturing bean that has merit not only as a seed producer but as a yielder of hay, as will be noted by referring to Tables 15 and 16.

Illini is an excellent seed producer at DeKalb and is also a good hay bean. In northern Illinois it seems to ripen later than Ito San. The difference is not great, probably three to five days. At Urbana there is very little difference in the length of season required for these two varieties to mature.

An early strain of Manchu, commonly referred to as Illinois Manchu, is one of the promising varieties for northern Illinois. It is a heavy yielder of seed in most years but has the disadvantage of requiring the entire season to mature a seed crop and consequently is sometimes caught by frost.

TABLE 15.—DEKALB FIELD: SOYBEAN HAY PRODUCTION
Annual yields of the different varieties and their percentage ratings using Ito San as the standard for comparison
(Tons per acre)

Variety	1919	1921	1923	1924	1925	1926	Percentage rating
Sherwood	2.62	....	....	....	....	....	192.6
Wilson	2.10	....	....	....	....	....	154.4
Nuttal	1.91	....	....	....	....	....	140.4
AK2	....	....	....	....	2.85	....	119.7
AK	1.68	....	2.29	....	....	....	117.5
Ebony	1.99	1.49	2.22	....	....	....	114.0
Mongol	....	1.83	....	....	....	....	113.0
Wisconsin Black	....	1.69	1.85	....	3.19	....	111.8
Chestnut	1.83	1.59	2.16	....	....	....	111.6
Black Eyebrow	....	1.62	1.98	....	2.57	....	102.5
Manchu	....	2.04	1.95	....	2.09	....	101.0
Ito San	1.36	1.62	2.02	1.29	2.38	....	100.0
Mandarin	....	....	1.45	....	2.16	....	81.8
Illini	....	....	....	....	1.82	....	76.5

TABLE 16.—DEKALB FIELD: SOYBEAN HAY PRODUCTION
Comparable average yields of the different varieties, using Ito San as the standard for comparison
(Tons per acre)

Variety	Number of years compared	Years on which comparison is based	Average yield
Ito San	5	1919, 1921, 1923, 1924, 1925.	1.73
Ito San	3	1919, 1921, 1923	1.67
Chestnut	3	1919, 1921, 1923	1.86
Ebony	3	1919, 1921, 1923	1.90
Ito San	3	1921, 1923, 1925	2.01
Manchu	3	1921, 1923, 1925	2.03
Wisconsin Black	3	1921, 1923, 1925	2.24
Black Eyebrow	3	1921, 1923, 1925	2.06
Ito San	2	1919, 1923	1.69
AK	2	1919, 1923	1.99
Ito San	2	1923, 1925	2.20
Mandarin	2	1923, 1925	1.80
Ito San	1	1925	2.38
AK2	1	1925	2.85
Illini	1	1925	1.82
Ito San	1	1921	1.62
Midwest	1	1921	1.83
Ito San	1	1919	1.36
Nuttal	1	1919	1.91
Sherwood	1	1919	2.62
Wilson	1	1919	2.10

Hay Production.—Varieties that mature late can be grown in northern Illinois for hay, whereas it is unsafe to attempt to grow them

for seed. The trials at DeKalb having been started primarily to find well-adapted seed-producing strains, the hay yields are no doubt below those which could have been secured had more typical hay varieties of somewhat later maturity been selected. Black Eyebrow, Manchu, and Illini have been among the better hay producers of the early beans. These varieties when thickly seeded make a satisfactory yield of a medium quality hay. Ebony, Midwest, and Peking while too late for seed production make good hay yields under northern Illinois conditions.

Performance of Varieties in Central Illinois

Seed Production.—Ebony is used as a standard at Urbana because it is a dependable bean and also because it has been in the trials for a longer period than any other variety now grown. While it does not produce as high yields of seed as some other varieties, it ranks well in hay production and has proved a consistent yielder. This variety is therefore one of the good general-purpose beans for this section of the state. Of the 29 varieties listed in Table 17, only 8 have proved superior to the standard as seed producers.

Elton, the highest yielding variety in the South-Central rotation, is a yellow-seeded medium-early bean which has never proved commercially popular. The seed is large, the oil content about average, but the pods have a distinct tendency to shatter.

A. K., the next highest producer, has been a popular bean and is still grown quite extensively. The objection to the old type lies in the fact that it is really a mixture of many types, some early, some late, some short, some tall. This variation in growth and maturity makes

FIG. 14.—A THIRTY-FOUR BUSHEL CROP OF ILLINIS ON THE UNIVERSITY FARM

These beans were seeded at the rate of 40 pounds to the acre, a grain drill being used and the rows spaced 28 inches apart. The beans stand approximately 36 inches high.

TABLE 17.—URBANA FIELD: SOYBEAN SEED PRODUCTION IN SOUTH-CENTRAL ROTATION

Annual yields of the different varieties and their percentage ratings using Ebony as the standard for comparison

(Bushels per acre)

Variety	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	Percentage rating
Elton	....	....	....	....	....	....	15.2	13.5	....	27.6	16.2	16.4	19.4	25.1	18.8	39.5	24.8	23.7	32.1	34.6	27.6	119.5
AK	....	....	....	....	....	....	....	....	20.0	27.8	16.1	9.4	19.3	24.9	20.0	39.4	24.2	24.5	27.8	28.3	....	119.1
Hong Kong	....	....	....	....	26.7	27.6	15.6	16.3	....	25.0	17.8	15.7	24.0	....	18.7	38.9	27.8	20.7	17.6	30.3	33.5	116.5
Manchu	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	36.1	21.1	29.8	27.5	25.2	27.1	114.0
Ilsoy	....	....	....	....	....	....	....	....	....	....	....	....	....	22.3	19.2	32.2	20.6	16.6	....	....	....	106.6
Haberlandt	....	....	....	15.7	33.1	33.2	....	16.1	26.2	20.0	14.1	9.0	16.7	23.6	15.2	32.5	24.1	18.4	10.0	27.5	34.3	104.4
Amherst	13.0	11.5	18.5	20.7	27.0	24.8	15.5	....	....	....	....	....	....	....	....	....	....	....	....	....	....	101.9
Jet[1]	....	....	....	....	24.8	22.0	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	101.7
Virginia	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	33.5	24.4	16.4	13.7	25.2	....	100.0
Ebony	**16.0**	**12.9**	**15.3**	**22.9**	**24.6**	**22.3**	**14.9**	**14.8**	**19.3**	**20.2**	**10.6**	**17.7**	**16.1**	**20.1**	**19.1**	**32.1**	**19.3**	**13.4**	**16.6**	**32.2**	**32.7**	**100.0**
Ito San	16.2	15.8	9.6	15.3	16.8	12.5	....	....	....	24.0	16.1	18.2	20.6	15.5	20.8	29.3	20.0	27.5	23.6	20.4	....	97.9
Hamilton	....	....	....	....	....	....	....	....	....	....	....	....	....	15.3	20.2	29.6	19.2	26.0	14.2	24.5	29.0	96.4
Wilson	....	....	....	....	25.8	23.4	12.0	17.2	....	18.7	12.9	8.4	17.3	....	....	....	....	....	....	....	....	96.3
Black Eyebrow	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	32.6	16.1	25.5	22.3	20.3	23.3	95.8
Sherwood	....	....	....	....	25.0	28.2	....	15.6	....	16.0	10.6	7.7	17.8	....	....	....	....	....	....	....	....	95.7
Illinois 13-181	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	19.4	13.1	26.6	....	95.2
Meyer[1]	....	....	....	....	24.2	28.7	12.3	16.5	....	15.8	11.7	5.0	16.8	....	....	....	....	....	....	....	....	93.0
Midwest	....	....	....	....	....	....	....	....	....	....	....	....	....	20.5	16.4	28.2	18.0	....	....	....	29.1	91.0
Illini	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	29.3	89.6
Guelph	11.3	14.1	14.9	16.7	21.8	22.2	....	15.4	16.7	19.0	8.1	14.5	14.2	....	....	....	....	....	....	....	....	88.8
Morse	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	16.8	10.7	27.2	....	88.4
Dunfield	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	28.2	86.2
Aksarben	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	27.8	85.0
Peking (Sable)	....	....	....	....	....	....	....	....	....	....	....	....	....	20.3	12.2	22.1	17.8	....	....	....	....	79.9
Ill. Pl. Br. 2289	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	26.1	79.8
Hurrelbrink	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	11.3	22.3	30.6	78.8
Wea	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	25.7	78.6
Columbia	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	13.7	9.3	21.8	....	72.0
Ogemaw	7.3	4.0	6.4	4.1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	32.5

[1]These varieties no longer being commercially available are omitted from the variety descriptions.

TABLE 18.—URBANA FIELD: SOYBEAN SEED PRODUCTION IN SOUTH-CENTRAL ROTATION
Comparable average yields of the different varieties using Ebony as the standard for comparison
(Bushels per acre)

Variety	Number of years compared	Years on which comparison is based	Average yield
Ebony	21	1907-1926	19.7
Ebony	17	1906-1911, 1915-1925	19.5
Ito San	17	1906-1911, 1915-1925	19.0
Ebony	17	1909-1911, 1913-1926	20.8
Haberlandt	17	1909-1911, 1913-1926	21.8
Ebony	15	1910-1913, 1915-1918, 1920-1926	20.4
Hong Kong	15	1910-1913, 1915-1918, 1920-1926	23.8
Ebony	14	1912, 1913, 1915-1926	20.0
Elton	14	1912, 1913, 1915-1926	23.9
Ebony	12	1914-1925	19.7
AK	12	1914-1925	23.5
Ebony	12	1906-1911, 1913-1918	17.7
Guelph	12	1906-1911, 1913-1918	15.7
Ebony	8	1910-1913, 1915-1918	17.7
Meyer	8	1910-1913, 1915-1918	16.4
Wilson	8	1910-1913, 1915-1918	17.0
Ebony	8	1919-1926	23.2
Hamilton	8	1919-1926	22.4
Ebony	7	1910, 1911, 1913, 1915-1918	18.0
Sherwood	7	1910, 1911, 1913, 1915-1918	17.3
Ebony	7	1906-1912	18.4
Amherst	7	1906-1912	18.7
Ebony	6	1921-1926	24.4
Manchu	6	1921-1926	27.8
Black Eyebrow	6	1921-1926	23.4
Ebony	5	1919-1922, 1926	24.7
Midwest	5	1919-1922, 1926	22.4
Ebony	5	1919-1923	20.8
Ilsoy	5	1919-1923	22.2
Ebony	5	1921-1925	22.7
Virginia	5	1921-1925	22.6
Ebony	4	1906-1909	16.8
Ogemaw	4	1906-1909	5.5
Ebony	4	1919-1922	22.7
Peking (Sable)	4	1919-1922	18.1
Ebony	3	1923-1925	20.7
Illinois 13-181	3	1923-1925	19.7
Morse	3	1923-1925	18.3
Columbia	3	1923-1925	14.9
Ebony	3	1924-1926	27.2
Hurrelbrink	3	1924-1926	21.4
Ebony	2	1910, 1911	23.5
Jet	2	1910, 1911	23.9
Ebony	1	1926	32.7
Wea	1	1926	25.7
Ill. Pl. Br. 2289	1	1926	26.1
Illini	1	1926	29.3
Aksarben	1	1926	27.8
Dunfield	1	1926	28.2

harvesting difficult. Many new strains selected from the old A. K. are now being studied and some of them are very promising.

Other good seed-producing varieties in the South-Central rotation are: Hong Kong, a late, yellow-seeded bean; Manchu, an early bean; Ilsoy, a late hay type; and Haberlandt, a late seed bean.

A summary of the seed yields in this rotation arranged according to comparable years under test is given in Table 18. It will be noted

FIG. 15.—A PROMISING CROP OF MANCHUS

This plot was seeded at the rate of 41 pounds to the acre in 28-inch rows. Note that it is impossible at this stage of development to distinguish between the rows.

that Ebony and Ito San head the list for number of years grown, Ebony having been included at Urbana for twenty-one consecutive and Ito San having been included for seventeen years.

The seed yields of the 30 varieties in the Northwest rotation are given in Table 19. Here, as in the South-Central rotation, Ebony is used as a standard. The variety trials have been somewhat irregular in this rotation, owing to the fact that in several seasons Ito San was grown on all plots either for hay or for seed. Beginning in 1921 variety studies were included annually in this rotation.

In addition to Elton, A. K., Manchu, and Hong Kong, which proved among the highest yielders of seed in the South-Central rotation, eight other varieties, Illini, Dunfield, Mansoy, Wea, Aksarben, Morse, Virginia, and Illinois 13-181, have proved higher than Ebony.

A summary of the seed yields in this rotation, based on comparable years, is given in Table 20. While considerably higher than the yields in the South-Central rotation, those shown here are for a shorter period and probably do not represent so well as the South-Central rotation what the average corn-belt farm will produce.

TABLE 19.—URBANA FIELD: SOYBEAN SEED PRODUCTION IN NORTHWEST ROTATION

Annual yields of the different varieties and their percentage ratings using Ebony as the standard for comparison

(Bushels per acre)

Variety	1910	1911	1917	1921	1922	1924	1925	1926	Percentage rating
AK	....	....	....	....	....	....	48.4	....	150.8
Illini	....	....	....	....	....	40.6	50.9	40.5	149.2
Mansoy	....	....	....	....	....	....	....	46.0	137.7
Dunfield	....	....	....	....	....	36.0	37.5	38.5	126.6
Wea	....	....	....	....	....	35.9	33.0	....	125.0
Aksarben	....	....	....	....	....	33.0	35.6	....	124.3
Hong Kong	....	....	....	....	....	....	....	39.6	118.6
Morse	....	....	....	38.2	29.7	....	....	39.7	110.6
Virginia	....	....	....	....	....	....	....	36.1	108.1
Illinois 13-181	....	....	....	39.2	28.2	....	....	....	105.3
Elton	32.2	18.8	15.8	....	....	....	....	....	105.2
Nuttal[1]	25.2	28.3	13.0	....	....	....	....	....	104.7
Ebony	**23.0**	**28.1**	**12.6**	**36.8**	**27.1**	**23.0**	**32.1**	**33.4**	**100.0**
Ilsoy	....	....	....	....	....	....	....	33.2	99.4
Wilson	....	....	12.6	35.8	....	....	....	....	98.0
Swan[1]	19.1	29.9	12.7	....	....	....	....	....	97.2
Peking	....	....	....	....	....	19.9	27.7	36.0	94.5
Columbia	....	....	....	34.6	26.1	....	....	29.9	93.1
Wilson V	....	....	....	....	22.5	20.1	30.5	31.9	90.8
Midwest	....	....	....	....	....	....	29.2	30.0	90.4
Hurrelbrink	....	....	....	27.9	27.4	....	....	....	86.6
Mikado[1]	....	....	....	....	....	....	27.7	....	86.3
Arlington	....	....	....	32.8	22.9	....	21.8	28.7	82.1
Lexington	....	....	....	....	....	....	24.5	28.9	81.5
Tashing[1]	24.4	13.4	12.8	....	....	....	....	....	79.7
Wisconsin Black	....	....	....	....	18.3	26.3	20.9	....	79.6
Flat King[1]	21.3	18.4	....	....	....	....	....	....	77.7
Habaro[1]	27.2	12.0	....	....	....	....	....	....	76.6
Mandarin	....	....	....	22.5	19.5	....	....	....	65.6
Ogemaw	13.6	23.0	....	....	....	....	....	....	32.4

Note—Seed yields were not secured in 1923 because of the necessity of harvesting the crop early since the field was to be seeded to alfalfa, which is a regular crop in this rotation.

[1]These varieties no longer being commercially available are omitted from the variety descriptions.

TABLE 20.—URBANA FIELD: SOYBEAN SEED PRODUCTION IN NORTHWEST ROTATION
Comparable average yields of the different varieties using Ebony as the standard for comparison
(Bushels per acre)

Variety	Number of years compared	Years on which comparison is based	Average yield
Ebony	8	1910, 1911, 1917, 1921, 1922, 1924-1926	27.0
Ebony	4	1921, 1922, 1925, 1926	32.4
Arlington	4	1921, 1922, 1925, 1926	26.6
Ebony	4	1922, 1924-1926	28.9
Wilson V	4	1922, 1924-1926	26.2
Ebony	3	1924-1926	29.5
Illini	3	1924-1926	44.0
Dunfield	3	1924-1926	37.4
Peking	3	1924-1926	27.9
Ebony	3	1921, 1922, 1926	32.4
Morse	3	1921, 1922, 1926	35.9
Columbia	3	1921, 1922, 1926	30.2
Ebony	3	1910, 1911, 1917	21.2
Elton	3	1910, 1911, 1917	22.3
Nuttal	3	1910, 1911, 1917	22.2
Swan	3	1910, 1911, 1917	20.6
Tashing	3	1910, 1911, 1917	16.9
Ebony	3	1922, 1924, 1925	27.4
Wisconsin Black	3	1922, 1924, 1925	21.8
Ebony	2	1910, 1911	25.5
Ogemaw	2	1910, 1911	8.3
Habaro	2	1910, 1911	19.6
Flat King	2	1910, 1911	19.9
Ebony	2	1917, 1921	24.7
Wilson	2	1917, 1921	24.2
Ebony	2	1921, 1922	32.0
Illinois 13-181	2	1921, 1922	33.7
Hurrelbrink	2	1921, 1922	27.7
Mandarin	2	1921, 1922	21.0
Ebony	2	1924-1925	27.6
Aksarben	2	1924-1925	34.3
Ebony	2	1925-1926	32.8
Midwest	2	1925-1926	29.6
Lexington	2	1925-1926	26.7
Ebony	1	1925	32.1
Mikado	1	1925	27.7
AK	1	1925	48.4
Hoosier	1	1925	29.9
Ebony	1	1926	33.4
Virginia	1	1926	36.1
Hong Kong	1	1926	39.6
Mansoy	1	1926	46.0
Ilsoy	1	1926	33.2

Hay Production.—In the South-Central rotation nine varieties, Peking, Meyer, Hong Kong, Morse, Midwest, Columbia, Virginia, Ilsoy, and Hurrelbrink, rank 10 percent higher than Ebony as hay producers (Table 21). Peking and Virginia have the highest average yields, 2.56 and 2.52 tons to the acre respectively, while the average of all nine better yielders for 31 hay crops was 2.47 tons an acre. For a summary of the hay yields based on comparable years see Table 22.

TABLE 21.—URBANA FIELD: SOYBEAN HAY PRODUCTION IN SOUTH-CENTRAL ROTATION

Annual yields of the different varieties and their percentage ratings using Ebony as the standard for comparison

(Tons per acre)

Variety	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	Percentage rating
Peking	....	....	....	....	....	2.18	2.58	2.66	2.80	....	....	....	....	127.4
Meyer[1]	....	2.87	1.65	1.68	2.62	....	....	....	....	....	....	....	....	125.0
Hong Kong	2.12	2.56	1.75	2.09	2.40	....	1.84	3.09	3.03	2.70	2.47	2.40	2.14	121.4
Midwest	....	....	....	....	....	....	....	....	....	....	....	....	2.41	117.6
Morse	....	....	....	....	....	....	....	....	....	2.39	2.57	2.31	....	114.2
Columbia	....	....	....	....	....	....	....	....	....	2.34	2.58	2.31	....	113.7
Virginia	....	....	....	....	....	....	....	3.03	2.81	2.59	1.78	2.39	....	112.5
Ilsoy	....	....	....	....	....	1.95	2.27	2.96	2.39	2.54	....	....	....	112.0
Hurrelbrink	....	....	....	....	....	....	....	....	....	....	2.22	2.14	2.81	111.4
Guelph	....	2.05	1.72	1.55	2.40	....	....	....	....	....	....	....	....	109.7
Wilson	....	1.87	1.75	1.19	2.84	....	....	....	....	....	....	....	....	108.5
Haberlandt	....	2.41	1.27	1.35	1.21	2.12	1.58	2.93	2.23	2.57	2.69	2.16	2.86	108.2
Illinois 13-181	....	....	....	....	....	....	....	....	....	2.11	2.42	2.31	....	107.5
Aksarben	....	....	....	....	....	....	....	....	....	....	....	....	2.20	107.3
Sherwood	....	2.13	1.27	1.37	2.61	....	....	....	....	....	....	....	....	104.5
AK	....	2.10	1.57	.98	1.64	1.89	1.40	2.20	2.17	3.07	2.69	2.40	....	103.1
Hamilton	....	....	....	....	....	1.30	1.97	2.17	2.05	2.44	2.09	1.91	2.70	101.5
Elton	1.59	2.14	1.42	1.38	1.50	1.89	1.57	2.41	2.47	2.82	2.26	2.27	1.56	100.5
Ebony	**1.64**	**1.62**	**1.59**	**1.91**	**1.91**	**1.63**	**1.57**	**2.70**	**2.12**	**2.08**	**2.24**	**2.05**	**2.05**	**100.0**
Ito San	....	1.98	1.27	1.21	1.68	1.56	2.04	2.15	2.00	2.62	1.78	1.93	....	94.4
Ill. Pl. Br. 2289	....	....	....	....	....	....	....	....	....	....	....	....	1.99	97.1
Manchu	....	....	....	....	....	....	....	1.91	1.72	2.60	1.63	1.50	1.59	82.8
Black Eyebrow	....	....	....	....	....	....	....	2.10	1.43	2.21	1.85	1.54	1.40	79.6
Illini	....	....	....	....	....	....	....	....	....	....	....	....	1.54	75.1
Dunfield	....	....	....	....	....	....	....	....	....	....	....	....	1.53	74.6
Wea	....	....	....	....	....	....	....	....	....	....	....	....	1.47	71.7

[1]This variety no longer being commercially available is omitted from the variety descriptions.

TABLE 22.—URBANA FIELD: SOYBEAN HAY PRODUCTION IN SOUTH-CENTRAL ROTATION
Comparable average yields of the different varieties using Ebony as the standard for comparison
(Tons per acre)

Variety	Number of years compared	Years on which comparison is based	Average yield
Ebony	13	1914-1926	1.93
Ebony	13	1914-1926	1.93
Elton	13	1914-1926	1.94
Ebony	12	1914-1918, 1920-1926	1.96
Hong Kong	12	1914-1918, 1920-1926	2.38
Ebony	12	1915-1926	1.96
Haberlandt	12	1915-1926	2.12
Ebony	11	1915-1925	1.95
Ito San	11	1915-1925	1.84
AK	11	1915-1925	2.01
Ebony	8	1919-1926	2.05
Hamilton	8	1919-1926	2.08
Ebony	6	1921-1926	2.21
Manchu	6	1921-1926	1.83
Black Eyebrow	6	1921-1926	1.76
Ebony	5	1921-1925	2.24
Virginia	5	1921-1925	2.52
Ebony	5	1919-1923	2.02
Ilsoy	5	1919-1923	2.42
Ebony	4	1915-1918	1.76
Wilson	4	1915-1918	1.91
Sherwood	4	1915-1918	1.84
Meyer	4	1915-1918	2.20
Guelph	4	1915-1918	1.93
Ebony	4	1919-1922	2.00
Peking	4	1919-1922	2.56
Ebony	3	1923-1925	2.12
Morse	3	1923-1925	2.42
Columbia	3	1923-1925	2.41
Illinois 13-181	3	1923-1925	2.28
Ebony	3	1924-1926	2.11
Hurrelbrink	3	1924-1926	2.36
Ebony	1	1926	2.05
Aksarben	1	1926	2.20
Ill. Pl. Br. 2289	1	1926	1.99
Midwest	1	1926	2.41
Illini	1	1926	1.54
Dunfield	1	1926	1.53
Wea	1	1926	1.47

Straw Production.—Soybean straw is recognized as a valuable roughage on most farms. Growers are interested, therefore, in the amount of straw which different varieties will produce. This information for the South-Central rotation is given in Table 23. It will be noted that Peking, Ilsoy, Morse, Hong Kong, Hurrelbrink, and Virginia have produced from 24 to 45 percent more straw to the acre than the standard, Ebony. Some of the high seed-producers, notably A. K., Manchu, Illini, and Elton, produce less straw than does the standard.

TABLE 23.—URBANA FIELD: SOYBEAN STRAW PRODUCTION IN SOUTH-CENTRAL ROTATION

Annual yields of the different varieties and their percentage ratings using Ebony as the standard for comparison

(Tons per acre)

Variety	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	Percentage rating
Peking	....	....	....	....	....	....	....	....	....	....	....	....	1.52	2.21	1.76	1.20	....	....	....	...	145.8
Ilsoy	....	....	....	....	....	....	....	....	....	....	....	....	1.58	1.80	1.53	1.76	1.60	....	....	...	139.7
Morse	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1.70	1.88	1.51	...	139.3
Meyer	....	....	....	1.73	1.45	1.28	.79	....	1.79	1.27	1.56	.99	....	....	....	....	....	....	....	...	135.1
Hong Kong	....	....	....	2.13	1.38	.93	.73	....	1.54	1.11	1.31	1.63	....	1.74	1.53	1.40	1.50	1.65	1.27	.6	128.3
Hurrelbrink	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1.48	.96	1.6	125.0
Virginia	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1.64	1.31	1.61	1.57	1.07	...	124.1
Sherwood	....	....	....	1.52	1.68	....	.85	....	1.22	.93	1.63	1.41	....	....	....	....	....	....	....	...	123.4
Aksarben	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1.1	122.2
Haberlandt	....	....	.78	2.15	1.42	....	.83	1.33	1.36	.94	1.43	.80	1.32	1.30	1.18	1.13	1.25	1.45	1.27	2.2	117.1
Midwest	....	....	....	....	....	....	....	....	....	....	....	....	1.19	1.31	1.28	1.09	....	....	....	1.4	113.5
Illinois 13-181	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1.44	1.66	1.03	...	113.1
Columbia	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1.46	1.10	1.25	...	104.1
Hamilton	....	....	....	....	....	....	....	....	....	....	....	....	.87	1.02	1.39	1.03	1.52	1.43	.79	1.3	101.7
Wilson	....	....	....	1.26	.87	.62	.84	....	1.06	1.00	1.26	1.23	....	....	....	....	....	....	....	...	101.2
Dunfield	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.9	100.0
AK	....	....	....	....	....	....	....	1.14	1.35	.91	.84	.99	1.23	.88	1.09	.96	1.41	1.42	1.51	...	100.0
Ebony	**1.07**	**.79**	**1.18**	**1.34**	**1.04**	**.55**	**.69**	**1.00**	**.86**	**.98**	**1.19**	**1.39**	**1.30**	**1.15**	**1.12**	**1.02**	**1.33**	**1.00**	**1.34**	**.9**	**100.0**
Elton	....	....	....	....	....	.51	.62	....	1.15	.82	1.22	.93	1.12	1.04	1.16	1.15	1.36	1.14	1.01	.9	95.3
Amherst	.63	.95	.74	1.43	.95	.76	....	....	....	....	....	....	....	....	....	....	....	....	....	...	91.5
Ito San	.97	.79	.75	1.69	1.07	....	....	....	1.15	.88	1.16	.93	.78	.83	1.20	.98	.73	1.14	1.40	...	91.2
Illini	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.8	88.9
Ill. Pl. Br. 2289	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.8	88.9
Jet	....	....	....	1.16	.94	....	....	....	....	....	....	....	....	....	....	....	....	....	....	...	88.2
Guelph	.52	.75	.66	1.30	.88	....	.71	.99	1.03	.97	1.05	.73	....	....	....	....	....	....	....	...	83.2
Manchu	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1.19	.78	1.03	.90	.78	.9	83.0
Black Eyebrow	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1.00	.80	.84	.86	1.16	.8	81.3
Wea	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.7	77.8
Ogemaw	.49	.48	.20	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	...	38.5

TABLE 24.—URBANA FIELD: SOYBEAN STRAW PRODUCTION IN SOUTH-CENTRAL ROTATION

Comparable average yields of the different varieties using Ebony as the standard for comparison

(Tons per acre)

Variety	Number of years compared	Years on which comparison is based	Average yield
Ebony	20	1907-1926	1.06
Ebony	17	1909-1911, 1913-1926	1.11
Haberlandt	17	1909-1911, 1913-1926	1.30
Ebony	16	1907-1911, 1915-1925	1.13
Ito San	16	1907-1911, 1915-1925	1.03
Ebony	15	1910-1913, 1915-1918, 1920-1926	1.06
Hong Kong	15	1910-1913, 1915-1918, 1920-1926	1.36
Ebony	14	1912, 1913, 1915-1926	1.06
Elton	14	1912, 1913, 1915-1926	1.01
Ebony	12	1914-1925	1.14
AK	12	1914-1925	1.14
Ebony	11	1907-1911, 1913-1918	1.05
Guelph	11	1907-1911, 1913-1918	.87
Ebony	8	1910-1913, 1915-1918	1.01
Meyer	8	1910-1913, 1915-1918	1.36
Wilson	8	1910-1913, 1915-1918	1.02
Ebony	8	1919-1926	1.15
Hamilton	8	1919-1926	1.17
Ebony	7	1910, 1911, 1913, 1915-1918	1.07
Sherwood	7	1910, 1911, 1913, 1915-1918	1.32
Ebony	6	1907-1912	1.00
Amherst	6	1907-1912	.91
Ebony	6	1921-1926	1.12
Manchu	6	1921-1926	.93
Black Eyebrow	6	1921-1926	.91
Ebony	5	1919-1923	1.18
Ilsoy	5	1919-1923	1.66
Ebony	5	1921-1925	1.16
Virginia	5	1921-1925	1.44
Ebony	5	1919-1922, 1926	1.10
Midwest	5	1919-1922, 1926	1.26
Ebony	4	1919-1922	1.15
Peking	4	1919-1922	1.67
Ebony	3	1923-1925	1.22
Morse	3	1923-1925	1.70
Illinois 13-181	3	1923-1925	1.38
Columbia	3	1923-1925	1.27
Ebony	3	1924-1926	1.08
Hurrelbrink	3	1924-1926	1.35
Ebony	3	1907-1909	1.01
Ogemaw	3	1907-1909	.39
Ebony	2	1910, 1911	1.19
Jet	2	1910, 1911	1.05
Ebony	1	1926	.9
Aksarben	1	1926	1.1
Dunfield	1	1926	.9
Illini	1	1926	.8
Ill. Pl. Br. 2289	1	1926	.8
Wea	1	1926	.7

TABLE 25.—URBANA FIELD: SOYBEAN STRAW PRODUCTION IN NORTHWEST ROTATION

Annual yields of the different varieties and their percentage ratings using Ebony as the standard for comparison

(Tons per acre)

Variety	1910	1911	1917	1921	1922	1924	1925	1926	Percentage rating
AK	....	....	....	....	....	....	1.41	...	135.6
Lexington	....	....	....	....	....	....	1.44	2.1	134.1
Arlington	....	....	....	1.69	1.81	....	1.52	2.1	133.8
Aksarben	....	....	....	....	....	1.48	1.58	...	133.0
Ilsoy	....	....	....	....	....	....	....	2.1	131.3
Peking	....	....	....	....	....	1.61	1.40	1.9	126.2
Morse	....	....	....	1.37	1.55	....	....	2.3	121.7
Wilson	....	....	.68	1.60	....	....	....	...	121.3
Midwest	....	....	....	....	....	....	1.20	1.9	117.4
Virginia	....	....	....	....	....	....	....	1.8	112.5
Wisconsin Black	....	....	....	....	1.21	1.41	1.59	...	111.1
Wilson V	....	....	....	....	1.54	1.42	1.30	1.6	108.9
Columbia	....	....	....	1.45	1.59	....	....	1.6	108.4
Swan[1]	1.73	1.24	.89	....	....	....	....	...	103.2
Illini	....	....	....	....	....	1.32	1.18	1.4	100.3
Hong Kong	....	....	....	....	....	....	....	1.6	100.0
Ebony	**1.72**	**1.34**	**.70**	**1.18**	**1.50**	**1.25**	**1.04**	**1.6**	**100.0**
Hurrelbrink	....	....	....	1.22	1.44	....	....	...	99.3
Mikado[1]	....	....	....	....	....	....	1.00	...	96.2
Wea	....	....	....	....	....	1.12	1.09	...	95.7
Dunfield	....	....	....	....	....	1.41	1.12	1.2	95.4
Nuttal[1]	1.51	1.37	.68	....	....	....	....	...	95.2
Manchu	....	....	....	....	....	....	....	1.5	93.8
Illinois 13-181	....	....	....	1.17	1.11	....	....	...	85.1
Flat King[1]	1.47	1.01	....	....	....	....	....	...	81.1
Elton	1.28	.97	.78	....	....	....	....	...	80.8
Habaro[1]	1.47	.87	....	....	....	....	....	...	76.5
Tashing[1]	.96	.69	.81	....	....	....	....	...	65.6
Mandarin	....	....	....	.64	.74	....	....	...	51.5
Ogemaw	.68	.18	....	....	....	....	....	...	28.1

[1]These varieties no longer being commercially available are omitted from the variety descriptions.

A summary of the straw yields in this rotation, based on comparable years, is given in Table 24. With most varieties a yield of approximately one ton of straw to the acre is what may reasonably be expected.

In the Northwest rotation Peking, Ilsoy, Morse, and Midwest, four varieties which show a relatively high yield of straw on the South-Central rotation, are from 17 to 31 percent better than the standard (Table 25). Other varieties showing relatively high yields of straw for a period of two or more years are Lexington, Arlington, Aksarben, and Wilson. For a summary of yields based on comparable years see Table 26.

TABLE 26.—URBANA FIELD: SOYBEAN STRAW PRODUCTION IN NORTHWEST ROTATION

Comparable average yields of the different varieties using Ebony as the standard for comparison

(Tons per acre)

Variety	Number of years compared	Years on which comparison is based	Average yield
Ebony	8	1910, 1911, 1917, 1921, 1922, 1924-1926	1.29
Ebony	4	1922-1926	1.35
Wilson V	4	1922-1926	1.47
Ebony	4	1921, 1922, 1925, 1926	1.33
Arlington	4	1921, 1922, 1925, 1926	1.78
Ebony	3	1924-1926	1.30
Peking	3	1924-1926	1.64
Illini	3	1924-1926	1.30
Dunfield	3	1924-1926	1.24
Ebony	3	1921, 1922, 1926	1.43
Morse	3	1921, 1922, 1926	1.74
Columbia	3	1921, 1922, 1926	1.55
Ebony	3	1922-1925	1.26
Wisconsin Black	3	1922-1925	1.40
Ebony	3	1910, 1911, 1917	1.25
Swan	3	1910, 1911, 1917	1.29
Nuttal	3	1910, 1911, 1917	1.19
Elton	3	1910, 1911, 1917	1.01
Tashing	3	1910, 1911, 1917	.82
Ebony	2	1924, 1925	1.15
Aksarben	2	1924, 1925	1.53
Wea	2	1924, 1925	1.10
Ebony	2	1925, 1926	1.32
Lexington	2	1925, 1926	1.77
Midwest	2	1925, 1926	1.55
Ebony	2	1917, 1921	.94
Wilson	2	1917, 1921	1.14
Ebony	2	1921, 1922	1.34
Hurrelbrink	2	1921, 1922	1.33
Illinois 13-181	2	1921, 1922	1.14
Mandarin	2	1921, 1922	.69
Ebony	2	1910, 1911	1.53
Flat King	2	1910, 1911	1.24
Habaro	2	1910, 1911	1.17
Ogemaw	2	1910, 1911	.43

Differences Among and Within Soybean Varieties

More than two thousand varieties and strains of soybeans have been studied and described in the United States. Of this list only a comparatively few have proved promising. The majority were new introductions tested out by the U. S. Department of Agriculture and discarded after a few years of trial as of no economic importance. Forty-five varieties and more than a hundred new strains have been tested on the experiment fields of the University of Illinois, and more than half of them have been found sufficiently promising to justify their continuance in the trials for a time.

The determination of the best variety for a given region or purpose is not a simple task. Yield and maturity are naturally the most important characteristics, but there are several other considerations, such as habit of growth, coarseness of stem and branches, leafiness, tendency to retain foliage, ease of shattering, and color of seed, that must be weighed.

Varietal characters are always more or less variable and any description of a variety must be so interpreted. For example, maturity to the inexperienced grower frequently suggests a rather definite thing, 105 days meaning 105 days. As a matter of fact, the time necessary for a variety to mature varies markedly according to environmental conditions. It is perhaps most strikingly affected by time of planting but is also influenced by the different strains, by seasonal conditions, and by source of seed. As an illustration, there are two strains of Manchu grown at Urbana, one of which matures in 100 to 105 days, while the other requires 115 to 120 days.

Time for Maturing.—Soybeans seeded in early May will mature somewhat earlier than those seeded in June, but the difference in time of maturity will not be so great as the difference in planting dates. At the Tennessee Station[18*] it was found, as a result of a two-year trial, that Mammoth Yellow, Midwest, and Ito San varieties seeded April 2 and 3 required 187, 149, and 121 days respectively to mature, while the same varieties seeded July 15 and 16 required 102, 84, and 84 days respectively. Mammoth Yellow, under Tennessee conditions, performed rather consistently both years. The last planting, July 16, was 104 days after the first, April 3, but the first planting matured only 24 days sooner. Neither Midwest nor Ito San was so consistent for the two years. Midwest the first year had a spread of 106 days at planting and 26 days at maturity, in the second year, 104 days at planting and 63 days at maturity. Ito San was even more variable, having a planting date spread of 103 days the first year and a harvesting variation of 56 days, while the second year the spreads were 104 days and 74 days respectively. These data should not be interpreted, however, as assurance that late-seeded beans will hasten their

maturity sufficiently to be safe under Illinois conditions. Furthermore it should be pointed out in this connection that late-planted soybeans are, as a rule, considerably less productive both of hay and of seed, and that the quality of seed produced from a late-planting is likewise below that for the medium dates for planting.

The source of the seed affects the time that soybeans mature in much the same manner that it affects corn. The extent of such variation will probably not be so noticeable as with corn, but nevertheless it is important. Manchu seed from Michigan compared with the same strain grown for a number of years in southern Illinois will usually be found to be several days earlier in maturing.

Size of Seed.—This is another varietal character which is more or less variable. The size is affected by the stand, the method of planting, thoroness of inoculation, freedom from weeds, and seasonal conditions Thoroly inoculated soybeans will produce seed of larger and better quality than poorly inoculated plants or those not inoculated at all. A variety of soybeans growing without weed competition will produce a larger bean of apparently higher quality than the same variety handicapped by weeds or grasses, even tho all other conditions are the same. Seasonal conditions are also likely to affect materially the size of the seed. A variety which requires practically all the season to ripen normally will have larger, plumper seed in years in which the fall months are favorable for maturity than in years in which cool weather sets in earlier than normal, forcing the beans to hasten their maturity.

Size of Stem.—This characteristic, like size of seed, is affected by the soil type, the method and rate of planting, and the competition of weeds or companion crops. Fertile soils tend to make a coarser stem than the medium to thin soils. Thin planting has the same tendency. Competition with weeds or with companion crops tends to reduce the size of the stem and also the number of leaves. While thick planting may reduce the size of the seed, it will also reduce the size of stem, thus improving the quality of the hay.

Erectness of Plant.—While the richer soils have a tendency to increase the size of the stem and the height of the plant, plants grown on the less fertile soils are inclined to be somewhat shorter and more erect. Varieties which have a tendency to lean or droop, especially on the richer soils, are likely to exhibit less of this tendency when grown on less fertile soils and often would be definitely classed as erect.

Susceptibility to Mottling.—Soil and climatic conditions seem to affect more or less definitely this characteristic. Some of the yellow-seeded varieties—Ito San, Midwest, Haberlandt, and Hurrelbrink—seem to mottle much more readily at Urbana than A. K., Illini, Elton, and Aksarben, altho when seeded on the experiment fields of southern Illinois they seem to produce seed which is only slightly mottled.

Choice of Variety.—There is no one item in soybean production more important than the choice of the variety to be grown. During the early period of soybean production in this state there were but few varieties from which a choice could be made; now there are many and it is possible to find one or more varieties for almost any set of conditions. The U. S. Department of Agriculture is constantly importing new types from foreign lands and plant breeders are doing their share in creating new strains.

Description of Varieties

In view of the foregoing statements it undoubtedly is clear that one cannot expect a varietal description of a soybean to agree in every detail with seeds and plants produced in widely different places and under varying conditions of soil, season, and culture. Descriptions given here apply primarily to the varieties as grown on the University South Farm at Urbana. The older, more common varieties have been grown on the South-Central rotation at Urbana, where the soybean is the only legume in a four-year rotation following three years of corn. The beans are seeded at the rate of 30 pounds to the acre in 28-inch rows. The new varieties and strains have been tested on the Northwest rotation in a much more fertile soil and in a better rotation. Here soybeans follow corn in a soybean, potato, corn combination, these crops being rotated twice and then moved to an alfalfa sod. As in the South-Central rotation, the beans are grown in rows. The growth in this latter rotation is more vigorous and there is a tendency to produce plants which are coarser as well as later in maturing but which still produce an excellent grade of seed.

One of the most difficult characters to describe accurately is the color of the seed coat and hilum of the different varieties and strains. A bean classed as yellow by one investigator might be buff to another. To eliminate this personal factor, the colors of the various beans here described are based on Ridgeway's "Color Standards and Color Nomenclature." Not all color names so applied are in common usage; so in order to make them intelligible to those who do not have access to Ridgeway's charts, a more commonly descriptive name of the tint or shade, where that seems to be helpful, is given in parentheses immediately following the color name derived from Ridgeway.

Another character usually referred to in any seed description is the relative size of seed. This likewise is subject to considerable variation according to the observations of different investigators. Seasonal conditions, methods of seeding, and the character of the soil, as previously pointed out, also have some influence on the size of the seed. In order to eliminate as far as possible all differences in size except differences in variety, samples of seed were used to determine relative sizes produced in rows on the South Farm at Urbana and the

figures shown are the average sizes of the crops of three years. The following arbitrary standards for descriptive terms for size of seed were adopted:

	Seeds per pound
Large seed	less than 2,000
Medium-large seed	2,000 to 3,000
Medium seed	3,000 to 4,000
Medium-small seed	4,000 to 5,000
Small seed	more than 5,000

In order to get a more definite standard by which the relative amounts of mottling under Urbana conditions could be expressed, arbitrary percentages were established and are used in the variety descriptions which follow. The beans were divided into two lots; into one was placed the seed which apparently was free from mottling, into the other was placed all seed which had unmistakable patches of superimposed pigment. The range in amounts of mottling allowable under the several groupings was as follows:

Slightly mottled	from 0 to 25 percent
Moderately mottled	from 26 to 50 percent
Strongly mottled	from 51 to 75 percent
Badly mottled	from 76 to 100 percent

A. K.

Adaptation.—Progeny of a commercial lot of beans imported from Manchuria in 1912 by the Lucas Paint Company. Made up of a number of strains varying in maturity from very early (90-day) to late (130-day) but averaging a medium-maturing (110-day) bean well suited for both hay and seed production. Appears best adapted to the medium-fertile to fertile soils of the central half of the state. Well suited for hogging-off with corn of medium maturity. There is some shattering of the earlier maturing strains but, as a whole, this bean holds the seed well. It stands up well on fertile soils.

Plant and Seed Characters.—Plants moderately erect as an average; stems medium in size; leaves vary in size and texture in different strains; pubescence both tawny and gray; flowers both purple and white, varying with the different strains which make up the composite; pods vary in color, ranging from brown to gray; seed size ranges from small to medium-large (averaging 2,751 per pound), shape oblong to spherical; seed coat cream buff to cream, only slightly mottled under Urbana conditions, hilum varies from cream color thru various shades of brown to slate black; cotyledons yellow. An area of irregular shape and size and of a shade (chamois) somewhat darker than the seed coat is frequently noted on the back.

Aksarben

Adaptation.—Introduced from Eakumen, Manchuria, by U.S.D.A. in 1913. Found to be a medium-early (105-day) seed type of bean. Well adapted to the medium-fertile soils of central and northern Illinois. Well suited for hogging-off with early corn. At maturity inclined to lose considerable seed by shattering.

Plant and Seed Characters.—Plants erect; stems rather large; leaves medium size; pubescence gray; flowers both purple and white; pods yellowish or straw color, well distributed along the stem; seed medium-large (2,338 per pound), oblong to almost spherical in shape; seed coat colonial buff (pale orange-yellow)

to cream buff, moderately mottled under Urbana conditions; hilum pinkish cinnamon to cinnamon; cotyledons yellow.

Amherst

Adaptation.—Amherst was one of the early soybean importations, having been first brought to this country by the U.S.D.A. in 1900 from Tokio, Japan; a second lot from the same source followed the next year. This is a medium-late (125-day) seed type of bean which appeared to be adapted to the fertile soils of central Illinois but was dropped in 1912 after having failed for six years to exhibit any special merit.

Plant and Seed Characters.—Plants stout, erect, bushy; leaves relatively large; pubescence tawny; flowers purple; pods tawny and tending to be crowded or bunched in central zone of plant; seed medium size (2,850 per pound),[1] oblong, and much flattened; seed coat straw yellow in color; hilum dark brown; cotyledons yellow.

Arlington

Adaptation.—Introduced by the U.S.D.A. from Paotingfu, China, in 1908. Under Illinois conditions it is a medium-late (125-day) bean of a hay type, well adapted to the medium-poor to poor soils of south-central and southern Illinois. Is probably too late for dependable seed production north of the Terre Haute-St. Louis line. At maturity it is likely to lodge badly on rich soils but on poorer soils stands satisfactorily.

Plant and Seed Characters.—Plants moderately erect, stems small and tending to twine at the tips; leaves medium in size; pubescence both tawny and gray; flowers both purple and white, varying with the different strains which, in commercial stocks, usually are mixed; pods brown and well distributed from near base to near tip of plant; seed small (5,292 per pound), oblong, and much flattened; seed coat black; hilum dusky purplish gray; cotyledons yellow.

Black Eyebrow

Adaptation.—Introduced from Wulukai, Manchuria in 1911. Has proved a medium-early (105-day) seed type of bean well adapted to the corn-belt soils of central and northern Illinois. An excellent variety for hogging-off with early corn, and in northern Illinois makes satisfactory yields of seed or hay. At maturity is inclined to hold the seed well and does not lodge so badly as some varieties.

Plant and Seed Characters.—Plants medium-erect; stems rather large; leaves medium size; pubescence tawny; flowers both purple and white, varying with the different strains which appear to be mixed in the commercial stock; pods brown; seed medium-large (2,291 per pound); seed coat peculiarly marked, having a black saddle of irregular proportions over a seed coat which varies from pinkish buff (pale orange-yellow) thru tawny olive (darker orange-yellow); hilum a dusky purplish gray, almost black; cotyledons yellow.

Chestnut

Adaptation.—Selected in 1907 at the Arlington Experiment Farm from the Habaro variety introduced by the U.S.D.A. the previous year. A medium-early (105-day) seed type of bean adapted to seed and early hay production in northern Illinois but not so good a seed producer under central Illinois conditions as a number of other varieties.

Plant and Seed Characters.—Plants stout, erect, and bushy; leaves medium size; pubescence tawny; flowers purple; pods tawny and tending to be crowded

[1]Supplied by W. J. Morse, U. S. Department of Agriculture.

or bunched in central zone of plant; seed medium size (2,560 per pound), oblong and slightly flattened; seed coat Brussels brown (yellowish orange) to Argus brown (darker orange brown); hilum bone brown (dark reddish brown) to Natal brown (slightly reddish brown); cotyledons yellow.

Columbia

Adaptation.—Introduced by the U.S.D.A. from Poatingfu, China, in 1908. A medium-late (125-day) hay type well adapted to soils of medium to low fertility. Will mature a satisfactory seed crop in southern Illinois and is a good hay variety in the central part of the state. On rich soils is inclined to lodge readily.

Plant and Seed Characters.—Plants of a twining type; stems small; leaves medium-small; pubescence gray; flowers both purple and white; pods grayish and well distributed along the stem; seed medium-small (4,720 per pound), oblong and somewhat flattened in shape; seed coat chrysolite to jade green (from light to dark greenish yellow), moderately mottled under Urbana conditions; hilum blackish brown; cotyledons green.

Dunfield

Adaptation.—Introduced by the U.S.D.A. from Pauchiatun Station, Manchuria, in 1913. A medium-early (105-day) bean, apparently quite satisfactory for both hay and seed production, well adapted to the medium-fertile to fertile soils of the corn belt. Well suited for hogging-off with early corn. Stands up well at maturity and does not lose seed readily.

Plant and Seed Characters.—Plants moderately erect; stems and leaves medium size; pubescence gray; flowers both purple and white; pods brown; seed medium-large (2,750 per pound), oblong to almost spherical in shape; seed coat cream buff (pale orange-yellow); hilum sorghum brown; cotyledons yellow.

Ebony

Adaptation.—One of the early importations of the present common varieties, having been introduced by the U.S.D.A. from Pingyang, Korea, in 1901. A medium-maturing bean (120-day) of a type well suited to either seed or hay production and adapted to a wide range of soils from southern to northern Illinois. Is one of the oldest and most widely known varieties in the state. Its wide distribution and popularity is probably due more to its dependability under all conditions than to superiority or excellence in any other single character.

Plant and Seed Characters.—Plants moderately erect, bushy; stems small; leaves medium-large; pubescence tawny; flowers both purple and white; pods brown and tending to be clustered in the central zone of the plant; seed medium-small (3,810 per pound) almost spherical in shape; seed coat black; hilum dark puplish gray; cotyledons yellow.

Elton

Adaptation.—Another of the early introductions, having been brought in from Khabarovsk, Siberia, by the U.S.D.A. in 1906. A medium-early (110-day) bean of a seed-producing type, apparently best adapted to the medium-fertile to fertile soils of central and northern Illinois. Is satisfactory wherever a relatively early variety is wanted. Stands well but shatters considerably after maturity.

Plant and Seed Characters.—Plants stout and erect; stems medium-large; leaves large; pubescence gray; flowers purple; pods tawny, seeds medium-large (2,398 per pound), oblong, slightly flattened in shape; seed coat pinkish buff (pale orange-yellow) and moderately mottled under Urbana conditions; hilum slightly darker in color than the seed coat; cotyledons yellow.

Guelph

Adaptation.—One of the early importations brought in from Japan in 1889 by W. P. Brooks, Massachusetts Agricultural Experiment Station. Proved to be a medium-maturing (115-day) bean of a seed type adapted to medium-fertile to fertile soils. Is not so generally grown now as it was a few years ago. Has the disadvantage of shattering badly when ripe and consequently is not especially desirable for seed production. Widely used for hay several years ago but has gradually been supplanted by more desirable types.

Plant and Seed Characters.—Plants erect and bushy; stems coarse; leaves large; pubescence tawny; flowers purple; pods brown and tending to be clustered in the central zone of the plant; seed medium size (2,483 per pound),[1] oblong, and somewhat flattened; seed coat deep chrysolite (yellowish) green to jade green in color, moderately mottled under Urbana conditions; hilum purple drab to dusky brown; cotyledons green.

Habaro

Adaptation.—Introduced by the U.S.D.A. in 1906 from Khabarovsk, Siberia. A medium-early (105-day) bean of a seed-producing type adapted to the medium-fertile to fertile corn-belt soils. Primarily a seed producer, maturing readily in the central and northern portions of the state; adapted, therefore, to seeding with early corn for hogging-off.

Plant and Seed Characters.—Plants erect and bushy; stems rather large and coarse; leaves medium size; pubescence both tawny and gray; both purple and white flowered plants are to be found in the mixed population; pods also are of two colors, tawny and gray; seed medium size (3,136 per pound),[1] oblong, slightly flattened; seed coat cream color; hilum deep brownish drab; cotyledons yellow.

Haberlandt

Adaptation.—Another of the old varieties, having been introduced from Pingyang, Korea, by the U.S.D.A. in 1901. A medium-late (125-day) seed type of bean, which seems well adapted to medium-poor to poor soils. Satisfactory as a seed producer in southern Illinois and is rather generally used there for hogging-off with corn, as it stands up well and does not shatter readily when ripe. Too late in maturing to be safe for seed production much north of a line drawn across the state from Terre Haute to St. Louis.

Plant and Seed Characters.—Plants erect and bushy; stems and leaves large, rather coarse; pubescence tawny; pods brown and borne in clusters in the central portion of the plant; seed medium-large (2,372 per pound), oblong, slightly flattened; seed coat maize yellow in color, considerably mottled under Urbana conditions; hilum dark grayish brown and cotyledons yellow. Much of the commercial seed of this variety includes both purple-flowered and white-flowered strains.

Hamilton

Adaptation.—A pure-line selection made by the Ohio Experiment Station in 1909 from a large, brown, late-maturing variety secured from the U.S.D.A. under number 23. A medium-late (125-day) seed type which seems to be well adapted to both medium-fertile and poor soils. Well suited to seed production in southern Illinois. Generally used in that section for hogging-off with corn, as it stands up well and does not shatter readily when ripe.

Plant and Seed Characters.—Plants stout, erect, and bushy; stems and leaves large and rather coarse; pubescence tawny; flowers purple; pods brown,

[1]Furnished by Morse.

tending to be grouped in clusters in central zone of plant; seed medium-large (2,645 per pound), oblong, and somewhat flattened; seed coat tawny olive to brown; hilum a dark purple drab; cotyledons yellow.

Hong Kong

Adaptation.—One of the older importations, having been introduced by the U.S.D.A. from Hong Kong, China, in 1908. A medium-maturing (120-day) variety which seems well adapted to either seed or hay production. Has been grown at Urbana since 1910. Has proved itself one of the high yielders of seed as well as hay. Seems best adapted to fertile soils. Has the disadvantage of lodging considerably on fertile soils and of losing its leaves rather early.

Plant and Seed Characters.—Plants stout and moderately erect; stems and leaves large and rather coarse; pubescence both tawny and gray; flowers both purple and white; pods tawny and crowded or bunched in central zone of plant; seed medium-large (2,833 per pound), oblong, and slightly flattened; seed coat colonial buff (pale orange-yellow) to cream buff and moderately mottled under Urbana conditions; hilum walnut brown (light red-brown) to chocolate brown; cotyledons yellow.

Hurrelbrink

Adaptation.—Probably a selection of Haberlandt made in 1902 by Frank Hurrelbrink of Taylorville, Christian county, Ill. A medium-late (125-day) seed type of bean which seems well adapted to soils of medium to low fertility. Well suited for seed production in south-central and southern Illinois. Generally considered to be especially adapted for growing in corn to hog-off because it stands up well and does not shatter readily when ripe.

Plant and Seed Characters.—Plant characters closely resemble those of Haberlandt. Seed is medium-large (2,890 per pound), slightly elliptical to almost spherical in shape; seed coat cream buff in color and considerably mottled at Urbana; hilum burnt umber (dark red-brown); cotyledons yellow.

Illini

Adaptation.—A pure-line selection made at the University of Illinois from the A. K. variety. Has proved a medium-early (105-day) seed type of bean in trials at Urbana and Alhambra. At DeKalb, however, it has not matured early enough to warrant its being recommended for that section. Would appear to be best adapted to central and southern parts of the state.

Plant and Seed Characters.—Plants moderately erect to erect; stems medium in size; pubescence gray; flowers white; pods yellow to light brown; seed coat straw yellow to amber yellow, only slightly mottled under Urbana conditions; hilum walnut brown; cotyledons yellow; seeds medium size (2,864 per pound), oblong to round.

Illinois 13-181

Adaptation.—A pure-line selection made at University of Illinois in 1913 from a plant found growing in a field of Ebony. A medium-late (125-day) variety. In yield tests on the Agronomy South Farm it has compared very favorably with the best standard varieties commonly grown in central Illinois.

Plant and Seed Characters.—Habit of growth erect and bushy, with rather thick, heavy stems. Pubescence tawny; flowers purple; pods brown; seed medium size (2,841 per pound); seed coat green; hilum dark brown; cotyledons yellow. Has a strong tendency to mottle. Pods borne comparatively high. A good seed type.

Ilsoy (Illinois 13-19)

Adaptation.—A pure-line selection originating from a plant found growing in a field of Ebony at the University of Illinois in 1913. Has been known for a number of years as Illinois 13-19. A medium-late (122-day) hay type of bean resembling the Virginia in habit of growth. Appears to be best adapted to conditions and soils in southern Illinois.

Plant and Seed Characters.—Plants viney and with tendency to lodge; stems slender, becoming twining at the tips; pubescence tawny; flowers purple; pods brown and well distributed along the stem; seed medium size (3,052 per pound), oblong, and flattened; seed coat Brussels brown (yellowish brown) in color; hilum carob (dark reddish brown) to Chestnut brown; cotyledons yellow.

Ito San

Adaptation.—One of the first commercially important soybeans; introduced by the Kansas Station in 1890. A medium-early (105-day) seed type of bean well adapted to the medium-fertile to fertile soils of central and northern Illinois. Is probably best suited for seed production and for hogging-off with an early corn. Has the disadvantage of shattering somewhat when mature.

Plant and Seed Characters.—Plants erect, bushy; stems medium large; pubescence tawny; flowers purple; pods brown and grouped in clusters in the central and lower zones of the plant; seed medium-large (2,616 per pound), oblong to almost spherical in shape; seed coat Naples yellow (light yellow-orange), moderately mottled under Urbana conditions; hilum slightly darker than seed coat, with a brown spot near one end; cotyledons yellow.

Jet

Adaptation.—Among the early soybean importations, having been brought in by the U.S.D.A. from Sachow, China, in 1906. A medium-maturing (115-day) hay type of bean, which was best adapted to the medium-fertile soils of the corn belt altho it produced satisfactory hay crops on poor soils. The Jet was a hay bean of some promise but because it was mixed and ranked only fair as a seed producer it lost favor over the corn belt.

Plant and Seed Characters.—Plants slender, tending to twine and with a distinct tendency to droop; leaves small; pubescence both brown and gray; flowers both purple and white; pods brown; seed medium-small (3,760 per pound),[1] oblong, and much flattened; seed coat black in color; hilum deep purplish gray with a brown line thru it; cotyledons yellow. The commercial seed of this variety seems to be made up of at least two different strains.

Lexington

Adaptation.—Selected in 1907 at the Arlington Experiment Farm from the Sherwood variety introduced the previous year by the U.S.D.A. A medium-late (125-day) hay type of bean adapted to production in south-central and southern Illinois. Under central Illinois conditions it is too late for safe seed production.

Plant and Seed Characters.—Plants medium stout, tending to be erect; leaves bushy and of medium size; pubescence gray; flowers both purple and white; pods grayish and well distributed; seed small (4,440 per pound), oblong with a slight tendency to flatten; seed coat olive yellow to deep colonial buff (deep buff with a very slightly greenish tint); hilum sorghum to Hays brown (red brown to a lighter reddish brown); cotyledons yellow.

Mammoth Yellow

Adaptation.—One of the early importations, but exact date and origin seems somewhat indefinite. A late-maturing (140-day) seed type of bean adapted to a

[1]Furnished by Morse.

wide range of soil conditions. Will mature a seed crop in an average season in the southern two tiers of counties in Illinois. A fairly satisfactory hay variety in this region and in most seasons is satisfactory as far north as Terre Haute, Effingham, and St. Louis as a hay crop and to grow with late corn for silage.

Plant and Seed Characters.—Plants erect, bushy; stems large and coarse; leaves medium size; pubescence gray; flowers white; pods straw yellow; seed medium-large (2,145 per pound),[1] almost spherical in shape; seed coat cream buff; hilum fawn color to bone brown (light to dark brown); cotyledons yellow.

Manchu

Adaptation.—Imported from Ninguta, Manchuria in 1911, has come to be one of the most popular beans of the corn belt. A medium-early (105-day) bean of a seed-producing type, well adapted to the medium-fertile to fertile corn-belt soils of central and northern Illinois. Well suited for hogging-off with early corn. At maturity this variety holds the seed well. It is inclined to lodge especially on rich land.

Plant and Seed Characters.—Plants moderately erect, bushy; stems rather large; leaves medium-large and coarse; pubescence tawny; flowers both purple and white varying with different strains; pods brown and well distributed from near the base to the very tip of the plant; seed medium-large (2,555 per pound), oblong to almost spherical in shape; seed coat colonial buff (yellowish orange), only slightly mottled under Urbana conditions; hilum usually slate, altho some commercial strains have a small percentage with a brown hilum; cotyledons yellow.

Mandarin

Adaptation.—Introduced from Peh-tuan-luitza, Manchuria, in 1911 by U.S. D.A. An early (100-day) seed type of bean, well adapted to medium-fertile to fertile soils. A satisfactory seed-producer in extreme northern Illinois, where it will mature a crop practically every year; in fact, this variety is sometimes objected to because it is too early for Illinois conditions.

Plant and Seed Characters.—Plants erect, bushy; stems and leaves medium size; pubescence gray; flowers purple; pods gray; seed medium-large (2,900 per pound),[1] almost spherical in shape; seed coat pinkish buff (pale orange-yellow); hilum a light clay (darker orange-yellow) to warm sepia (brown); cotyledons yellow.

Mansoy

Adaptation.—A pure-line selection of the Manchu made by U.S.D.A. at Arlington Experiment Farm, Virginia. Has proved to be a medium-maturing (115-day) bean in the trials carried on for the past three years. Is a seed type, producing heavy crops of seed in the central and south-central Illinois. In northern Illinois it is too late for seed but is adapted for hay, pasture, and ensilage. Breeds true for the black hilum characteristic, a thing never before commercially available.

Plant and Seed Characters.—Plants moderately erect to erect, bushy; stems rather large, leaves medium-large and coarse; pubescence tawny; flowers purple; pods brown and well distributed from near the base to the very tip of the plant; seed medium-large (2,450 per pound), slightly oblong to almost spherical; seed coat colonial buff (yellowish orange) and only slightly mottled under Urbana conditions; hilum slate color; cotyledons yellow.

Midwest

Adaptation.—Apparently identical with Medium Yellow, Mongol, Roosevelt, and the corn-belt variety known as Hollybrook. Introduced from central China

[1]Furnished by Morse.

in 1901 by U.S.D.A. A medium to medium-late (120-day) bean which seems best adapted to the fertile corn-belt soils. For a time was one of the most popular all-purpose beans in Illinois. Its decline in popularity was no doubt due to the fact it was too late for a safe seed crop and was not as good a yielder of seed as some of the newer varieties and strains. Is still favorably regarded by many farmers and widely grown for silage and hay and in corn for hogging-off.

Plant and Seed Characters.—Plants erect, bushy; stems medium to medium-large; leaves large; pubescence tawny; flowers purple; pods tawny and more or less clustered along the central to lower zones of the stem; seeds medium in size (3,604 per pound), oblong, slightly flattened; pinkish buff in color, badly mottled when grown at Urbana; hilum color varies from Mikado brown (light brown) to a warm sepia (dark brown); cotyledons yellow.

Morse

Adaptation.—Introduced from Newchwang, Manchuria, in 1913 by U.S.D.A. A medium-late (125-day) bean of a type well suited to either seed or hay. Does unusually well on poor soils and makes excellent yields of both hay and seed on medium-fertile soils. Considering its time of maturing and its yield of seed it probably is best adapted to south-central and southern Illinois. Probably the most serious criticism that can be made of this bean is that it lodges badly, especially on the better soils.

Plant and Seed Characters.—Plants medium-erect, bushy; stems large; leaves large; pubescence gray; flowers both purple and white; pods gray; seed medium size (3,172 per pound), elliptical in shape; seed coat lime green (yellowish green), moderately mottled when grown at Urbana; hilum fawn color; cotyledons yellow.

Ogemaw

Adaptation.—One of the early soybeans brought into the Middle West, having been introduced in 1902 by E. E. Evans of West Branch, Michigan. A very early (90-day) bean of a seed type, adapted to medium-fertile to fertile soils; is too early for most northern Illinois conditions. Sometimes used for an early seed crop or to plant with an extra-early corn such as Minnesota 13 for hogging-off.

Plant and Seed Characters.—Plants stout, erect, bushy; stems medium-large; pubescence tawny; flowers white; pods brown and produced in clusters; seed medium size (3,133 per pound),[1] oblong and slightly flattened; seed coat chocolate brown in color; hilum chocolate color; cotyledons yellow.

Peking

Adaptation.—A selection made in 1907 from the Meyer, which was introduced from Peking, China, by U.S.D.A. in 1906. A medium to medium-late (120-day) bean of a hay type growing well on practically all soil types; probably the best hay bean yet tested and also excellent for growing in corn for silage purposes. Is too late for safe seed production except in south-central and southern Illinois; suitable for hay, however, in all parts of the state.

Plant and Seed Characters.—Plants slender, erect, bushy; stems and leaves small; pubescence tawny; flowers both purple and white; pods tawny and well distributed along the stems; seed small (6,014 per pound), much flattened; seed coat glossy black; hilum dull black; cotyledons yellow.

Sherwood

Adaptation.—Introduced by U.S.D.A. from Tientsin, China, in 1906. A medium to medium-late (120-day) hay type of bean which seems to be able to

[1]Furnished by Morse.

adjust itself to soils of low fertility. Was grown at Urbana from 1910 to 1918 with a fair degree of success; was dropped from the variety trials in 1918, having averaged somewhat below the standard for the period of time under test.

Plant and Seed Characters.—Plants slender, moderately erect, tips drooping and tending to twine; pubescence gray; flowers both purple and white; seed coat straw yellow; seed medium size, elliptical, slightly flattened; hilum pale or light brown; cotyledons yellow.

Virginia

Adaptation.—A selection from the Morse made by representatives of the U.S.D.A. in 1907. A medium-late (125-day) bean of a hay type, doing unusually well on the poorer types of soil. Is too late for dependable seed production in central Illinois but is a good hay variety for this area. Has a tendency to lodge badly on rich soils but stands much better on the poorer soils, giving a surprisingly large yield of either hay or seed under such conditions.

Plant and Seed Characters.—Plants slender, twining; leaves medium size; pubescence tawny; flowers purple; pods tawny and distributed thruout the length of the long, slender stem; seed medium-small (4,092 per pound), oblong, much flattened; seed coat medal bronze (greenish brown) to Prouts brown (dark yellowish brown); hilum olive brown; cotyledons yellow.

Wea

Adaptation.—Introduced from Shuangchenpu, Manchuria, by U.S.D.A. in 1911. In the series of cooperative trials in which it was tried out it was found adapted to the Wea prairie in northern Indiana for which it was named. Is a medium-early (110-day) seed type of bean adapted to fertile soils of the northern half of the state. Probably best as an early, seed-producing bean but also recognized as having merit as an all-purpose bean. Stands erect and holds the seed fairly well, thus being adapted to use in corn for hogging-off.

Plant and Seed Characters.—Plants stout, erect, bushy; leaves medium size; pubescence gray; flowers purple; pods gray and clustered; seed medium-large (2,760 per pound), oblong, and somewhat flattened; seed coat cream color, moderately mottled when grown at Urbana; hilum Verona brown to warm sepia (brown to dark brown); cotyledons yellow.

Wilson

This is the mixed population out of which the Wilson V was selected. Is essentially the same in all characters as Wilson V except that it has both tawny and gray pubescence and both purple and white flowers. There is also considerable range in size, and the shape of seed varies from nearly oblong flat to nearly round. Plants also vary from erect, stout, bushy, to slender with twining terminal.

Wilson V

Adaptation.—A pure-line selection of the Wilson made by representatives of the U.S.D.A. in 1912. Is a medium-late (122-day) bean primarily of a hay type, doing unusually well on the poorer types of soil. As a hay bean may be grown all over the state; as a seed bean it makes a fair yield but is too late to be dependable north of the Terre Haute-St. Louis line.

Plant and Seed Characters.—Plants slender, medium-erect, tending to twine slightly at the tips; pubescence gray; flowers purple; pods gray and well distributed thruout the length of the rather long, slender stem; seed small (5,162 per pound), oblong, and much flattened; seed coat black; hilum black; cotyledons yellow.

Wisconsin Black

Adaptation.—A selection made at the University of Wisconsin from a variety introduced as the Early Black in 1898.[1] An early maturing (100-day) bean primarily of a seed type, seemingly best adapted to fertile soils. Suitable for growing with early corn for hogging-off where an early type of bean is required. Too early for and seemingly not well suited to central Illinois.

Plant and Seed Characters.—Plants medium erect, bushy; stems small; leaves medium size; pubescence tawny; flowers purple; pods brown and well distributed along the stem; seed medium-large (2,839 per pound), oblong, slightly flattened; seed coat black; hilum dull purplish black; cotyledons yellow.

COMMERCIAL UTILIZATION OF THE SOYBEAN CROP

The soybean, during its early history under corn-belt conditions, was considered primarily a forage or hay plant. Difficulties in harvesting the seed, lack of information regarding satisfactory methods of threshing, and the cost of threshing during those early years caused many farmers to grow the crop solely for hay. As a result, the early studies of the experiment stations were concerned with the value of soybean hay as compared with other common hays.

The utilization of native-grown soybeans in the commerce of North America is practically an untouched field. American manufacturers have almost unlimited possibilities with this crop. That the Orient has learned to appreciate the value of the soybean is evidenced by the fact that more than one hundred soybean products are known in China, Japan, India, and Manchuria. It is certainly reasonable to expect that under American conditions and with the initiative of American manufacturers, many new products will be developed.

A few of the more important soybean products have gradually found a place on the market in this country. Soybean cake or meal, flour, oil, and soy sauce have been available for some time. Until comparatively recently, however, these products were of oriental manufacture or were made from imported seed, which in many cases was of an inferior quality when received here, thus limiting their use. Fresh products from native-grown beans are now available and are being eagerly studied and used in increasing amounts.

During the last five years several soybean processing plants have been built. Three different processes, or methods, of oil extraction are now employed in these manufacturing plants. The products from each of these processes are being investigated and the relative value of the oil for various uses more definitely ascertained.

The oldest type of processing is that in which the ordinary hydraulic press is used to extract the oil. The meal obtained by this method is commonly referred to by farmers, in speaking of one of the

[1]Furnished by Morse.

standard concentrates, as "old process." This same process is widely used in the cotton belt for cottonseed oil extraction.

The screw type of expeller is a modified press in which the heated beans are ground and compressed at one operation. The other type of processing which has recently received considerable attention in the corn belt is the solvent method, by which the oil is extracted from the ground beans by means of some chemical solvent, such as naphtha, benzol, or ether. The oil-laden solvent is then collected, distilled, and recondensed, leaving as a residue the extracted oil.

Soybean Cake One of the Most Valuable Products

The cake or meal is the bulkiest and, thus far, one of the most valuable products of the processing operation. The oil, which is frequently spoken of as the chief product, will seldom equal in value the meal from a given amount of beans. An average ton of soybeans will yield approximately 250 pounds of oil and 1,600 pounds of cake or meal by the ordinary expeller or compress method. There is usually

TABLE 27.—PERCENTAGE COMPOSITION OF THREE NITROGENOUS CONCENTRATES[9*]

Concentrate	Protein	Fat	Extract	Fibre	Ash	Water
Soybean oil meal.....	43.2	6.6	29.5	5.3	4.9	10.5
Cottonseed meal.....	44.1	9.1	25.0	8.1	6.2	7.5
Linseed meal (old process)...	33.9	7.5	35.7	8.4	5.4	9.1

approximately a 150-pound loss per ton in moisture reduction and other milling losses. Figured on these proportions and on average market prices during 1924 and 1925, the meal from a given quantity of beans is approximately one-third more valuable than the oil.

The milling value, and indirectly the composition or feeding value of soybean oil meal, varies somewhat with the variety of bean processed, the soil on which the beans are grown, and the method of extraction. Some varieties average 22 percent of oil, while others run as low as 16 to 17 percent. The average of common varieties is approximately 19 percent. In general, as the fertility of the soil is increased, the yield of beans and the percentage of protein increase, while the oil content is correspondingly reduced. Observations at the University of Illinois indicate that beans grown on sweet soil will be higher in protein and lower in oil than the same variety grown on sour soil. The amount of the oil recovered will vary with the variety processed, since some varieties seem to release the oil more readily than others.

The comparative composition of soybean oil meal and the two feeds with which it is most frequently compared, cottonseed oil meal and linseed meal, is given in Table 27.

Soybean oil meal has been found to be an excellent commercial nitrogenous concentrate. Unfortunately a comparatively small amount

of this product has been available for feeding trials because the increasing acreage has annually required the bulk of the harvested beans for seed.

Market for Soybean Oil Increasing

Soybean oil is gradually making a place for itself in American commerce. The imported product available to American manufacturers was in some respects of a lower quality than the native product now available. It will no doubt take a few years to overcome some of the prejudices against soybean oil which have arisen out of experience with the imported product. Much of the oil from the Orient was crudely manufactured and slowly transported from the inland points to seaboard. These conditions naturally tended to increase the likelihood of the oil becoming rancid. Consequently much of the imported soybean oil in recent years found its way into low-grade soap stocks.

Thru processing native-grown beans in American plants it is now possible to place on the market an entirely different product, many outlets for which have already been found. Soybean oil can be employed in the manufacture of paints, enamels, varnishes, linoleum, soap stocks, rubber substitutes, glue, celluloid, printers' ink, glycerine, explosives, lighting and lubricating oils, as well as various food products. This list will no doubt be materially lengthened as native oil becomes more plentiful and manufacturers are assured of a regular supply of beans. As an illustration of new uses, and therefore increased demands for the soybean oil, one manufacturer has recently announced the perfecting of a new core oil from this source for use in foundry operations.

Soybean Products as Human Food

The soybean has for centuries been an essential part of the diet of the Chinese and Japanese people. The high protein content of the bean has enabled them to use it largely as a meat substitute. In fact one authority says:[2*] "The soybean is the only legume yet known which can really be called a true meat substitute, the proteins being more nearly like animal proteins than those of any other vegetable." Other beans and leguminous seeds when used in the human diet can be classed as meat savers only. With the soybean, therefore, to supply the protein portion of the diet and the rice a favorite carbohydrate food, the Orientals have been able to live very cheaply on an almost exclusively vegetable diet. The Orient has devised many dishes from soybeans, the beans being used in all conditions—fresh, dried, and fermented.

Soybean Oil.—Among food products, soybean oil has been used as salad oil and as a substitute for butter and lard. The use of the oil in salad and cooking was practically unknown in this country be-

fore the advent of local factories processing native beans. The fact that the composition of soybean oil more nearly approaches that of animal fat than does any other vegetable fat would seem to presage a great and growing interest in this product.

Soybean Flour.—Tho not yet a common commodity, soybean flour is perhaps one of the oldest soybean products on the American market. It has been used for many years in the manufacture of food products for diabetic persons, where a special food of low starch content is required. It has also been found to have wide adaptation in general invalid and infant dietetics. Soybean flour made by grinding the cake or meal after the oil has been removed is gaining favor and many potential users are becoming interested in it. Extensive trials by the Home Economics Department of the University of Illinois, by various other schools and departments of home economics, as well as by the U. S. Department of Agriculture, have shown that soybean flour can be successfully utilized in making bread, gems, muffins, biscuits, wafers, and crackers. The soybean flour utilized in this way is usually substituted for approximately one-fourth of the wheat flour in the recipe.

Dry Soybeans.—These can also be used for human food in much the same manner as navy and other dry beans. Palatability and ease of cooking vary with different varieties, but the flavor, while distinctly different from that of other beans, is not distasteful, and the dishes made from soybeans are usually very palatable. Light-colored beans, yellows and greens, are as a rule best for human food, since the varieties with darker seed coats have a stronger and less pleasant taste. The texture of the soybean as a rule is more compact than that of the navy or common garden bean, making the soybean somewhat more difficult to cook. The variety Easy Cook, introduced by the U. S. Department of Agriculture, has been found to cook as readily as navy beans after the customary pre-soaking. Soybeans should be soaked thoroly for at least 12 hours before being cooked. After soaking and boiling, the beans can be baked or used in bean soup or in other dishes in place of other dry beans.

Dry soybeans have also been used as substitutes for salted peanuts and for coffee. When prepared as a substitute for peanuts, the dry seed is first soaked in a 10-percent salt solution for ten or twelve hours and then roasted to a light brown color. Yellow and green seeded varieties are preferred, as they make a better appearing and more palatable dish.

Soybean "coffee" is made by grinding beans which have been roasted and prepared in the same manner as the coffee bean. Soybean coffee is reported[22*] to have been used in the United States during the Civil War as a coffee substitute. In the Orient this is a commercial product and can be purchased on the market.

Immature or Green Soybeans.—Beans in the green stage are nutritious and palatable. When about three-fourths grown they make an appetizing and excellent food if shelled and cooked like lima or other green beans. The pods are tough and not desirable for human food, and to facilitate their removal should be boiled for 5 or 10 minutes, then cooled and shelled. Further utilization of soybeans as a commercial canning crop will depend somewhat upon the production of satisfactory varieties. One or two varieties have thus far been introduced which seem to be promising, Easy Cook and Hahto offering the best prospects thus far.

There is undoubtedly a great opportunity to make more general use of the soybean as a human food. All attempts to so use it have thus far demonstrated its value. The chief reasons for the delay in introducing the soybean and its products into the American diet seem to be the inability, until recently, to get fresh material, the uncertainty from year to year as to the availability of seed for processing, and the natural reluctance of any race to change its dietetic habits.

EARLY HISTORY OF SOYBEAN PRODUCTION IN ILLINOIS.—The first published records pertaining to the production of soybeans at the Illinois Station are for 1897. These trials were mainly to ascertain the general adaptation of the crop rather than to study types or strains. Variety studies as such started in 1906. More than 200 varieties and strains have been tried out, but many proved unsatisfactory and were retained but one year. Only two of the original varieties, Ebony and Ito San (Medium Early Yellow), are still commercially important in Illinois.

Soybean production on Illinois farms apparently antedates the variety work at the Station. J. C. Utter, Mt. Carmel, began growing beans in 1890. W. H. Stoddard, in a paper before the Macoupin County Farmers' Institute in December, 1898, reported several years' experience with the crop. C. A. Rowe, Jacksonville, began to grow the crop in 1899. Ralph Allen, Delavan, and Frank Hurrelbrink, Taylorville, were also among the early growers.

Pioneer growers were located in central, south-central, and southern Illinois. In these areas production made considerable progress before any significant acreage was noted in northern Illinois. In fact, not until after 1919 did the acreage in the northern portion of the state make any appreciable gain. Since that date the acreage has steadily increased, and much greater production can be predicted now that earlier maturing varieties are available.

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