APRIL, 1934

BULLETIN No. 309

SOYBEANS IN IOWA FARMING

By ALBERT MIGHELL, H. D. HUGHES
and F. S. WILKINS

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

R. E. BUCHANAN, Director

AGRICULTURAL ECONOMICS SECTION
AND FARM CROPS SUBSECTION

AMES, IOWA

CONTENTS

SUMMARY

1. The Iowa soybean acreage, exclusive of that interplanted with corn, has expanded from 471 acres in 1919 to 192,000 acres in 1933. The acreage planted with corn reached a peak in 1923 and since has dropped to about one-fifth of the former total.

2. Thirty-five percent of the crop is harvested as seed, while 65 percent is cut for hay. The percentage harvested for seed has been declining.

3. It is estimated that in 1931 68 percent of the crop acreage was used to supply feed for cattle, 8 percent for hogs and 1 percent for horses, 5 percent to supply operators' own seed, and 18 percent was sold.

4. The crop seems particularly adapted to southeastern Iowa and to the dairy section, but because of the depression the relative importance of soybeans in northern and western Iowa has increased.

5. Soybeans make an ideal emergency crop. Whenever cropping plans go wrong, or the cash position of the farmer is endangered, more soybeans are grown.

6. Soybeans compete with other crops most successfully on acid soil low in nitrogen and organic matter. They hasten erosion on rolling land, however, and cannot compete with alfalfa, red clover and sweet clover on sweet soils.

7. Soybeans frequently level out labor requirements on southern and eastern Iowa farms but their cultivation conflicts with corn cultivation on western and northwestern Iowa farms.

8. A well-prepared seedbed, a suitable variety, a thick stand, timely control of weeds and inoculation are essential.

9. The Iowa Station recommends the following five general purpose varieties for both seed and hay: Manchu, Illini, Dunfield, Mukden and Black Eyebrow.

10. Except for a delay of 2 to 3 weeks in planting, which makes possible an extra discing to kill the sprouting weeds, the best practice in the preparation of the seedbed for soybeans is the same as for corn.

11. In southern Iowa 88 percent of the crop was drilled solidly on the farms studied, 7 percent was broadcast, and 5 percent was planted with a corn planter.

12. The practice farmers in northern Iowa employ indicates that solid drilling has not proved suitable to that region. Planting in 21 or 28-inch rows with a four-row drill is the usual method when the bean crop has been accorded a permanent place in the cropping system. The corn planter is widely used as an emergency implement which saves investment in expensive equipment, but at the cost of more labor and lower yields.

13. Thick planting, 2 bushels when drilled solidly or at least 1 bushel per acre when planted in 42-inch rows, and at a depth of from 1½ to 2 inches, is very desirable.

14. The best time to plant soybeans is between May 15 and June 5 in southern Iowa, and between May 25 and June 5 in northern Iowa.

15. Inoculation is essential if soybeans are to be grown satisfactorily on soils which do not contain the soybean bacteria.

16. Particularly in northern Iowa, cultivation is essential to weed control. For beans in rows the harrow or rotary hoe should be used once, followed by as many cultivations with the corn cultivator as are needed. For soybeans drilled solidly, one to three times over with the harrow or rotary hoe is advised.

17. In harvesting soybeans for seed the use of a combine necessitates only one-third as much time as threshing and makes little or no change in cash costs. Harvesting with a combine may be much less costly than other methods if the acreage is sufficient and other conditions are favorable. Cutting with the binder, shocking and threshing is the method most frequently used, and is ordinarily fairly satisfactory. If the beans are cut with the mower and raked up, twine is saved but more labor is required, and the loss from shattering is greater.

18. In harvesting soybeans as hay, Iowa farmers use four methods, hand cocking, cocking with a rake, picking up with a hayloader after curing in the swath, cutting with the grain binder and curing in bundle shocks.

19. An average of 10.5 hours of labor was required to produce an acre of seed and 14 hours to produce an acre of hay on the farms studied. This is about three-quarters of the time required for corn under average Iowa conditions.

20. Basic facts needed for planning the soybean labor program and methods of evaluating probable results are given.

Soybeans in Iowa Farming [1]

By Albert Mighell, H. D. Hughes and F. S. Wilkins

Few other crops in Iowa have shown such rapid acreage increases as soybeans or proved as advantageous for so many different uses. Only 471 acres of the crop were grown in the state in 1919. By 1933 the area had expanded to 192,000 acres. Soybeans may be planted either alone or with corn. Alone, they may be used for seed, hay, pasture, silage, soiling, or as a green manure crop. The first two of these uses are by far the most important. Iowa farmers need a home-grown, high protein concentrate, and soybeans are the best crop available for that purpose. Soybeans also are grown extensively to provide a high protein roughage, because on many farms they are better suited to the soil and crop program than alfalfa and are more certain and productive than red clover.

SOYBEANS AS A CONCENTRATE

During the past 5 years, 1928 to 1932, from 25 to 40 percent of the soybean acreage in Iowa has been harvested for seed. Soybean seed, which is about one-third protein, is one of the few high protein concentrates which can be produced on Iowa farms. From 30 to 40 percent of the seed harvested is normally fed to livestock. The beans are a satisfactory feed for hogs, dairy cattle, beef cattle, sheep and chickens. Although, if fed in excessive amounts to hogs, they produce soft pork, when fed in limited quantities in the ration they may be used to advantage to replace a part of such purchased feeds as oilmeal and tankage. Soybean oilmeal will not cause soft pork. Especially

[1] The results of investigations by the Farm Crops Subsection on varieties and cultural practices were reported in Station bulletin 228, published in May, 1925. Certain of the results then reported are reviewed here and experiments continued in later years are reported to date. Recently (1932) cost studies of the soybean crop were made by the Agricultural Economics Section on 120 farms in representative regions. These cost studies and a preliminary survey of physical and economic factors on 150 farms, made in 1931, are also reported.

The authors are indebted to William G. Murray and H. L. Thomas for assistance in the economic phase of the study. Thanks are extended to the 150 Iowa soybean growers who kept labor and production records and furnished other facts in respect to their soybean enterprise in 1931 and 1932.

The Division of Forage Crops and Diseases, of the United States Department of Agriculture, cooperated in the variety studies.

when skimmilk is not available, Iowa farmers with much livestock can often afford to substitute soybeans for enough of the oat or corn acreage to supply at least part of the protein needed to balance their livestock rations.

Soybeans also are becoming a source of oil for commercial uses. In Iowa their use for oil, thus far, has been relatively small. Combined with the demand for seed, however, which in the past has taken between 25 and 40 percent of the beans harvested, this use should provide a more stable lower limit for seed prices.

The demand from mills for soybeans for oil extraction seems to be steady and dependable. Two mills in the state (1933), one at Centerville and another at Cedar Rapids, depend upon the Iowa crop. Some beans are sold to mills outside the state.

SOYBEANS FOR HAY

Soybeans are considerably more important for hay than for seed. From 60 to 75 percent of the acreage is now used for hay and there is a definite trend toward a larger proportion for that use. Soybeans are a desirable emergency legume hay crop when clover seedings fail. Also, on many farms, soybeans are used for hay in the regular rotation because they relieve the rush of work during the haying season in July and transfer it to the slack period in late August and September. This usually gives a decided advantage in labor distribution, except during corn cultivation when the work may pile up somewhat if the acreages of corn and beans are both large and the beans are grown in culivated rows.

Feeding tests indicate that, when considered on the basis of forage consumed, soybean hay has approximately the same feeding value as alfalfa. There is, however, somewhat more waste with the beans. Stock often refuse the coarser stems which constitute from 15 to 20 percent of the plant.

AN EMERGENCY CROP

On some Iowa farms soybeans have a permanent place, but on others they are an emergency crop. Only on soils low in lime, nitrogen and organic matter are soybeans to be advocated for the permanent crop rotation in preference to alfalfa, sweet

clover or red clover. But in an emergency, no other crop in Iowa compares with soybeans. Because it is an annual it may be substituted for the regular hay crop when seedings have failed. It also may be planted instead of corn or oats when the season has advanced too far to insure good yields of these crops. The ravages of insect pests, or the losses resulting from hail, or from excesses of water, often require some late planted substitute crop. The emergency character of the crop is one of its most important advantages.

Soybeans are essentially a "hard-times" crop. Tenants find them especially adapted where soybean hay can be substituted for alfalfa or where they can be planted instead of part of the oat acreage. While they require some cash for seed, often they tend to reduce the total cash requirements by supplying a home-grown high protein feed. Usually they have been a good cash crop also, since the price of soybean seed tends to be relatively high during a depression.

Although soybeans are especially valuable in maintaining farm income when physical or price conditions are unfavorable, they may lose this advantage when conditions improve again. In good times many farmers find red clover, alfalfa or sweet-clover a better crop than soybeans. When plans go wrong, however, and in "hard times," and when new investments must be held to a minimum, or when acid soil must be exploited temporarily, soybeans may be the best crop available. The more pressed the farmer becomes the more frequently will he find soybeans a desirable crop to grow.

EXPANSION OF THE SOYBEAN ACREAGE IN IOWA

RAPID INCREASES IN ACREAGE

Not until 1916 did Iowa farmers become sufficiently interested in soybeans to give them a trial. In 1919 the total soybean acreage in the state was only 471 acres, according to the United States census. Between 1919 and 1922 the acreage increased tenfold, making a total of 4,700 acres in 1922. The most marked growth of soybean acreage has taken place during the periods of greatest agricultural depression. Given a return of good times it would seem likely that a considerable slackening of the rate of increase could be expected. Figure 1

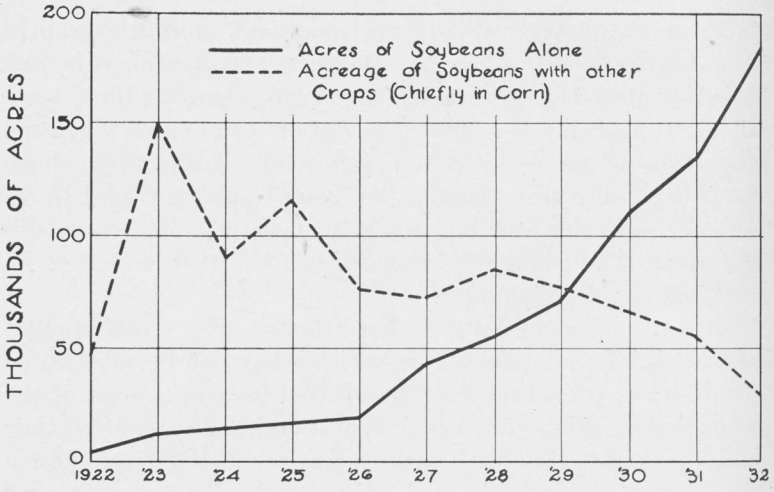

Fig. 1. Growth of the soybean acreage in Iowa.

shows the growth of the crop since 1922, ending with a total of 185,000 acres in 1932. By 1933 the acreage increased to 192,000. Of course the crop is still of relatively minor importance, since in the state as a whole less than one acre of soybeans is grown per farm.

During the depression of the early 1920's, soybeans were planted with corn very extensively, but since 1923 a decline in this use set in and has continued, until now the acreage planted with corn is less than one-fifth its former highest amount. The acreage of soybeans grown in silage corn has declined markedly. Although abandoned as a regular practice by many farmers, the planting of soybeans in corn to be harvested by livestock may be a profitable practice. For hogs or sheep turned in the cornfields, the soybeans and corn not only supply a more balanced diet than corn alone but often save labor and cash outlays.

RECENT CHANGES IN THE DISTRIBUTION OF THE SOYBEAN ACREAGE IN IOWA

The distribution of the Iowa soybean acreage is far from uniform. Of the two areas of higher concentration one lies in the dairy section of northeastern Iowa, centering in 12 counties around Waterloo, while the other lies in southern and south-

eastern Iowa. In the Wisconsin drift and Missouri loess areas of northwestern and western Iowa, conditions are favorable for other competing crops and as a result the eastern boundary of these two soil areas coincides rather closely with the western limits of the major soybean producing section of the state.

Farmers in southeastern Iowa were the first in the state to grow the crop extensively. Between 1926 and 1930 about 60 percent of the total state acreage of soybeans was in south central and southeastern Iowa and less than 30 percent in northeastern Iowa. In 1931 and 1932 the increase in acreage in southern Iowa nearly stopped, while the crop continued to expand in all other parts of the state. As a result, by 1932 there was practically as large an acreage of soybeans in northeastern as in southern Iowa. Bordering regions and western Iowa accounted for an increased proportion of the total for the state.

The seed market cannot be expected to hold up as well during the next 10 years as during the past, because the proportion of the crop used for seed is already declining, and this decline is almost certain to continue. In what parts of the state the saturation point in soybean production has already been reached and when it will arrive in other areas, cannot be fore-

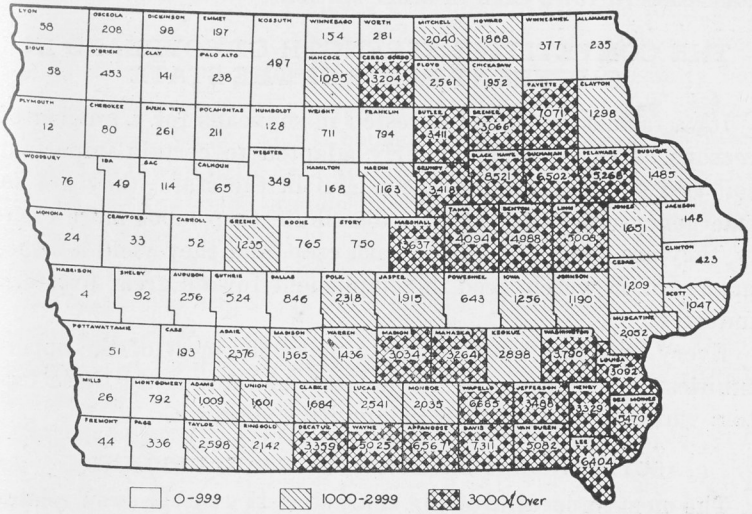

Fig. 2. The soybean acreage in Iowa in 1932.

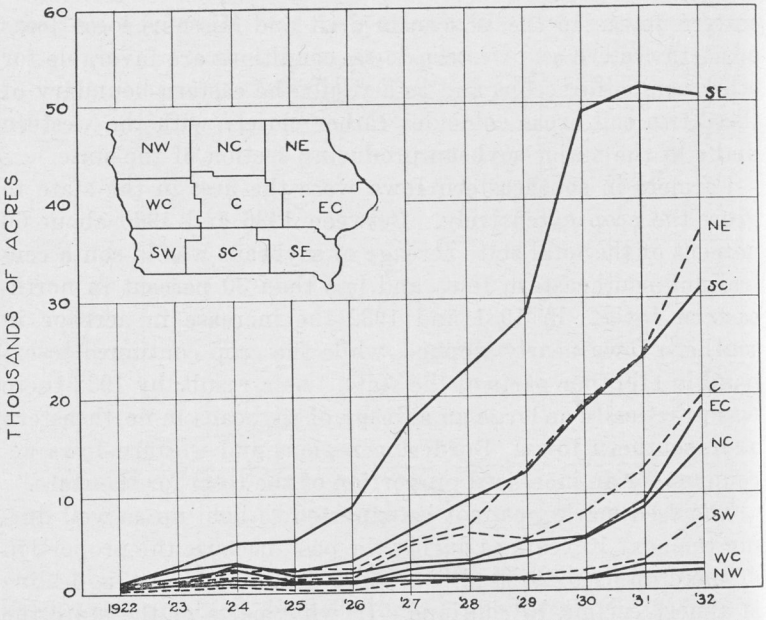

Fig. 3. Changes in the soybean acreage in different parts of the state. 1922-1932.

told; but certainly it seems that it will be much sooner in southeastern Iowa than in other sections.

THE COMPETITIVE STRENGTH OF SOYBEANS IN DIFFERENT PARTS OF THE STATE

Iowa farmers may be interested in soybeans for a number of reasons. They are particularly adapted to certain important soil and surface conditions common in the state, they are an emergency crop, they usually distribute crop labor more evenly, they are generally a good cash crop, and they yield a home-grown, high-protein feed to complement Iowa's great livestock industry.

Every producer who wishes to make the most of the opportunities they present should understand thoroughly those factors which determine their competitive strength.

SOYBEANS HASTEN EROSION OF ROLLING LAND

The most important of the characteristics of the crop relates to its adaptation to the soil and topography. Soybeans have

their greatest economic advantage on level, acid soils with relatively low natural fertility. The root system of the plant loosens the soil to an unusual degree, leaving the surface friable and easily eroded. Like corn, soybeans require a well-prepared seedbed, and usually cultivation after planting. This often results in excessive loss of surface soil. Particularly on the rolling and rough land of southern Iowa heavy soil losses from erosion often follow the soybean crop. This explains in part why the increase in the soybean acreage has ceased in that area recently, although the acreage is expanding rapidly elsewhere. If serious loss of the surface soil is to be avoided soybeans either should be grown only on relatively level land or definite steps should be taken to prevent soil erosion where they are grown. Planting winter wheat or rye as a winter cover crop on the soybean land in the fall is suggested as a desirable practice where soybeans are grown on rolling land.

SOYBEANS HAVE AN ADVANTAGE ON ACID SOILS LOW IN NITROGEN AND ORGANIC MATTER

The acidity, or lime requirement, of the soil is important in determining where the crop can be grown to advantage. On non-acid soils the soybean cannot successfully compete with sweet clover and alfalfa unless other conditions are unusually favorable to it. Even on moderately acid soils, where good stands of red clover can be obtained, that crop normally has kept out soybeans. High acidity is one of the chief reasons why the soybean acreage is concentrated in southeastern Iowa and in the Iowan drift area of northeastern Iowa. In these two regions getting good stands of red clover is often difficult, while the uncertainty of obtaining a stand and the expense of liming for sweet clover and alfalfa prevent many farmers from using these two crops. In such cases soybeans have a marked advantage, since vigorous growth and large yields of beans and hay can be had on soils so acid that the commonly grown clovers fail.

Soybeans produce relatively large yields, as compared with corn, oats and red clover on some of the less fertile soils in the state. This is a second reason why they have spread so rapidly in the northeastern or dairy section and in southern Iowa. In

central Iowa, soybeans yield only 10 to 15 percent more hay than red clover, while in southeastern Iowa they yield from 25 to 40 percent more.

SOYBEANS ARE A NEW FACTOR IN THE CROPPING PROGRAM

Soybeans are a new factor in the Iowa cropping program because they supply the farmer with a desirable emergency crop which he previously lacked. They may displace, in part, any one of his three most important crops, corn, small grain, or hay, if an emergency develops. Soybeans are often grown in the regular rotation, but they are most frequently introduced to overcome temporary conditions. This tends to prevent their long continuation in a specific use in the rotation and in the feed supply program.

Fig. 4. The acreage of soybeans planted with corn increased until 1923, after which time it decreased to one-fifth its former largest amount. Feeding trials indicate that there is little advantage in growing beans in corn.

Soybeans usually follow corn in the crop rotation. In the year after the soybean crop, corn is grown in about half the cases and small grain in the rest. In the dairy area and to a considerable extent in southern Iowa, soybeans are often followed by small grain.

The growing of oats after soybeans subjects the field to less erosion than corn after soybeans and makes it possible to seed

the land down at once. In the rougher areas of the state, where it is not desirable to till the better land for more than 2 years before it goes back to clover and grass, winter wheat has been found a better crop than oats following soybeans for it gives some protection against erosion during the winter.

On the richer and more level soils of central and southern Iowa, corn is the favorite crop to use after soybeans. Southern Iowa farmers report that corn after soybeans seems to yield unusually well, perhaps because of the fine physical condition of the soil. When corn follows soybeans plowing may often be dispensed with, thus saving some expense.

Seedlings of clover and grass tend to dry out and winterkill more often after soybeans than after corn, especially on poor or acid soils. In some sections of southern Iowa, where the surface is rolling and easily washed and also not sufficiently fertile to stand heavy cropping, this disadvantage of soybeans is now being recognized by most owner-operators. It is frequently difficult to get a stand of legume and grass seedings after soybeans in the dairy area also. The use of a roller or cultipacker to firm the surface after planting clover or grass, has been found to be particularly desirable on soybean ground. Some growers on level farms report that the way to avoid trouble from the failure of clover and grass seedings after soybeans is to follow them with corn for one year before seeding the small grain nurse crop.

SOYBEANS CHANGE THE LABOR PROGRAM

The introduction of soybeans into the cropping system tends to level out the peak points in the demand for labor and power on a majority of farms in southern and eastern Iowa and on some farms in western Iowa. Soybeans usually are planted between corn planting and corn cultivation time. This means that whatever cultivation they are given must compete with corn cultivation. In southern Iowa, where 40 acres of drilled beans can be cultivated in a day with a harrow and where the acreage in corn usually is limited by the amount of suitable corn land rather than by the labor supply, this competition for labor at corn cultivation time is of small consequence. But in western Iowa, where the acreage in corn is limited by the farmer's ability to tend it during the cultivation period, and

where the soybeans are frequently planted in rows, thus requiring about three cultivations with a corn cultivator, any addition to the total labor in June tends to limit the competitive advantage of the crop. This conflict for labor, plus the competition with alfalfa and sweet clover, which do well on sweet soils, has had a tendency to keep soybeans out of western and northwestern Iowa.

Within the last 5 years, however, a decided change has occurred in that section as a result of the all-purpose tractor. The labor peaks in spring work and at corn cultivation have been reduced on many farms, leaving the highest demands for labor at haying, harvest and threshing time. If this labor situation continues it may be expected that soybeans will become a considerably stronger competitor in that section than they have been in the past. This is particularly true in respect to their use as an emergency crop. The substitution of soybeans for small grain or hay, which is the usual one in northwestern Iowa, reduces the peak of labor at haying, harvesting and threshing and will transfer that demand for labor to the fall slack period after threshing and before corn husking. This is a most desirable arrangement for farmers of the cash grain area.

In the dairy section soybean hay harvest tends to interfere with silo filling. This is not a serious matter as soybeans may be put up any time during a 3-week period without serious consequences, and there is also considerable leeway in silo filling.

In all parts of the state, but particularly in the northwest, soybeans have a much greater competitive strength as an emergency crop than as a permanent crop.

RELATION OF SOYBEANS TO THE LIVESTOCK SYSTEM

Soybeans are utilized largely by livestock. This means that the kind of livestock kept on a given farm and in the neighborhood has an important bearing on the usefulness of soybeans and on the chances that they can be introduced advantageously into the crop rotation.

From the best estimates it seems that at least 65 percent of the soybean acreage in Iowa is used either directly or indirectly to supply feed for dairy cattle. An additional 20 per-

cent is used as feed for other classes of cattle, while about 10 percent of the total acreage is fed to hogs.

Soybeans are intimately related to the dairy industry. As will be seen in table I, in Fayette County, a strictly dairy area, practically the entire crop is used in providing soybean hay which dairymen find valuable in supplementing their rations. Certainly one of the important reasons why dairying has developed in southern Iowa is that soybeans have been found to provide a high protein roughage for that region. Soybeans are the only leguminous roughage which dairymen in the southern part of the state can grow on their poorer, acid soils without liming.

As indicated previously about one-third of the soybeans and soybean hay fed in the state are consumed by beef cattle and hogs. Soybeans are not used as a feed for hogs in northeastern Iowa because they cannot compete with skimmilk as a high protein supplement for pork production. But in other parts of the state surpluses of skimmilk are rare, and soybeans are often used instead of such purchased feeds as tankage, oilmeal and shorts. The danger of feeding soybeans to hogs is that soft pork will be produced. Two years results of feeding trials by

TABLE I. USE MADE OF SOYBEANS ON IOWA FARMS IN 1931 IN PERCENTAGE OF THE TOTAL ACREAGE HARVESTED AS SEED AND AS HAY.*

Use	State average		A dairy farming section (Fayette Co.)		A general livestock section (Tama Co.)		Southern Iowa (sample from four counties)	
	Seed	Hay	Seed	Hay	Seed	Hay	Seed	Hay
Dairy cattle	5	48	2	82	14	14	6	23
Other cattle	1	14	--	--	1	8	2	9
Hogs	8	--	2	--	14	--	18	--
Horses	--	1	--	--	--	--	--	1
For seeding	5	--	7	--	11	--	8	--
Sold	16	2	6	1	38	--	30	2
Total	35	65	17	83	78	22	64	36

* Data for this table were obtained from the Iowa Yearbook of Agriculture and from a survey of the use made of the soybean crop on 150 farms in selected areas in the state. Figures in columns one and two, except the totals, are estimates by the authors.

the Iowa Station have indicated that if soybeans constitute much over 5 percent of the total concentrates in the ration it is likely that soft fat will be produced.[2] Experienced farmers report that if whole soybeans are fed to hogs in proportions of less than 1 part to 10 of total concentrates there will be no harmful results. Soybean oilmeal has not been found to cause soft pork.

In tests at the Iowa Station, where one-third of the ration, or less, has been soybeans, no bad effects have been noted on the quality of the butter produced. Feeding beef cattle too heavy allowances of soybeans or rancid soybeans may result in the animals scouring or developing a dislike for the ration.

Practically without exception dairymen report soybean hay equal to alfalfa as a roughage for dairy cattle. Feeding trials substantiate this observation, basing the comparison on the pounds of hay consumed. It should be noted, however, that there is often considerable wasteage if the hay is not fine-stemmed.

RECOMMENDED VARIETIES OF SOYBEANS

Many varieties of soybeans can be grown with success in Iowa, but the Experiment Station advises Iowa farmers to confine their choice to the five well-known, high yielding, general purpose varieties—Manchu, Illini, Dunfield, Mukden and Black Eyebrow—for both seed and hay. All factors considered, the best seed beans are also the best hay beans.

A soybean survey made in six Iowa counties indicates that four of these, Manchu, Illini, Dunfield and Black Eyebrow, are being grown on approximately 95 percent of the farms, and it is believed that the same four predominate similarly in other sections of the state.

During the past 19 years 162 different varieties of soybeans and many hundreds of unnamed selections have been grown in the comparative tests at Ames. Many of these have been described in detail in Bulletin 228. All of them except Manchu, Illini, Dunfield, Mukden and Black Eyebrow have proved to be inferior as general purpose varieties for one or more rea-

[2] Information on feeding soybeans reported here was contributed by C. C. Culbertson of the Animal Husbandry Section and Dwight Espe of the Dairy Husbandry Subsection of the Iowa Agricultural Experiment Station.

Fig. 5. During the past 19 years, 162 different varieties of soybeans and hundreds of selections have been grown in comparative tests at Ames. Manchu, Dunfield, Illini, Black Eyebrow and Mukden have been found to be the varieties best suited to Iowa conditions, regardless of whether the crop is grown for seed or hay.

sons. Since 1924, variety trials have included only a limited group of the best previously tested varieties and such new varieties as have appeared since then.

Factors which may well be considered in choosing a variety are high yields of seed and hay, color, size, quality and non-mottling of seed, suitable maturity, erectness of plants, quality of hay and disease resistance. Furthermore, the variety must have the characteristic to stand ripe in the field for weeks if necessary without the seed shattering. The four varieties named above as now being grown almost exclusively in the state, together with the new variety, Mukden, rank high in practically all these characteristics. These varieties are approximately equal as producers of seed beans and also as hay varieties.

Yields of threshed beans from Mukden, Manchu, Illini, and Dunfield have been compared at the Iowa Agricultural Experiment Station, Ames, on 29 replications of machine-harvested plats as a total for the 4-year period 1929-32 (table 2). While the difference between Dunfield, the highest, and Manchu, the lowest of the group for this period, is 9 percent, no consistent advantage in yielding ability for the period is indicated, since for the longer 10-year period, 1922-33, the order was reversed and Manchu outyielded Dunfield by 1 percent.

TABLE 2. AVERAGE YIELDS OF VARIETIES TESTED FOR SEED.
(Yields given in bushels per acre for 8, 5, 4, 3 and 2-year periods.)

Variety	8-yr. Av. '25-32 incl.	4-yr. Av. '25-28 incl.	3-yr. Av. '25-27 incl.	2-yr. Av. '25-26 incl.	5-yr. Av. '28-32 incl.	4-yr. Av. '29-32 incl.
Black Eyebrow	---	29.4	27.3	29.2	---	---
Dunfield	25.7	30.0	28.0	30.0	24.3	24.6
Early Brown	---	---	27.1	29.5	---	---
Habaro	22.5	27.3	24.1	25.2	21.9	19.8
Habaro 13166	---	---	---	31.8	---	---
Illini	---	---	---	---	26.6	24.0
Manchu	26.5	30.3	29.1	32.8	24.9	22.6
Manchuria 13177	---	---	---	30.5	---	---
Manchuria 20173	---	---	---	30.2	---	---
Mukden	---	---	---	---	---	23.1
Pinpu	---	29.4	26.8	28.8	---	---
Soysota	---	---	25.0	28.5	---	---

TABLE 3. AVERAGE YIELDS OF VARIETIES TESTED FOR HAY.
(Yields in tons of air-dry hay per acre.)

Variety	7-year average 1925-32	3-year average 1925-27	4-year average 1929-32
Arlington	---	2.21	---
Dunfield	2.57	2.59	2.56
Habaro	---	---	2.07
Hong Kong	---	2.42	---
Illini	---	---	2.61
Illinois 13-19	---	2.26	---
Lexington	---	2.50	---
Manchu	2.36	2.38	2.35
Midwest	---	1.86	---
Mikado	---	2.33	---
Morse	---	2.50	---
Mukden	---	---	2.49
Peking	---	2.26	---
Virginia	---	2.24	---
Wilson	---	2.28	---

Yields of hay for the four varieties, Illini, Dunfield, Mukden and Manchu, compared in the trials at Ames averaged 2.61 tons per acre during the 4-year period, 1929-32 (table 3). As an average for the period Illini, Dunfield and Mukden exceeded Manchu by 11, 9 and 6 percent, respectively. Yields by individual years are shown in table 5. Illini outyielded Manchu in each of the 4 years, Dunfield 3 out of 4. Mukden outyielded Manchu 3 out of 4 years. While the differences among the four varieties are not statistically significant, Illini and Dunfield may be expected to yield more hay than Mukden and Manchu, particularly in southern Iowa. Illini and Dunfield are usually slightly later in maturing than Manchu and considerably later than Mukden. Thus they make more complete use of the growing season.

When Bulletin 228 was published in 1925 it was stated that Manchu had yielded 85 percent as much hay as the later, so-called, hay varieties—those which were too late to be depended upon for seed at Ames. The superiority of these hay varieties has not been evident in later tests. Manchu, with an average of 2.38 tons of air-dry hay per acre for the 3 years, 1925-27, exceeded Peking, Virginia, Wilson, Mikado, Midwest, Illinois 13-15 and Arlington, while it was only slightly inferior to Hong Kong, Lexington and Morse. Dunfield, with an average of 2.59 tons per acre, produced the highest yield for the 3-year period. This, however, was before Illini, an even higher yielding general purpose variety than Dunfield, was included in the tests. The varieties tested for hay in the earlier years of the period 1925-32 (table 5) include most of those which had produced the largest yields of hay previous to 1925.

In Missouri and southern Illinois, Virginia is recognized as the most productive seed variety on the poorest soils, and it is possible that this variety may have a place on the poorer soils of the southernmost counties of Iowa.

There are several reasons why the late-maturing hay varieties are grown but little in the state. In the first place none of them may be expected to yield as much seed as the prolific seed sorts in central Iowa, even in the most favorable season, and it is doubtful if the best of them will equal Illini, Dunfield and Manchu in seed yields even in the most southern Iowa

TABLE 4. COMPARATIVE YIELDS OF VARIETIES TESTED FOR SEED.

(Yields given in bushels per acre.)

Variety	1925	1926	1927	1928	1929	1930*	1931	1932
Black Eyebrow	35.8	22.9	22.1	34.2	---	---	---	---
Dunfield	36.3	24.9	24.7	36.0	19.3	11.0	26.1	30.3
Early Brown	31.2	27.2	23.3	---	---	---	---	---
Habaro	36.0	17.8	23.7	34.0	21.6	7.0	21.9	27.6
Habaro 13166	37.1	28.4	---	---	---	---	---	---
Illini	---	---	---	39.5	20.1	11.1	26.2	36.8
Iochu	38.8	---	---	---	---	---	---	---
Manchu	37.8	27.8	21.7	34.0	22.1	11.0	26.7	30.5
Manchuria 13177	38.7	23.2	---	---	---	---	---	---
Manchuria 20173	37.7	24.3	---	---	---	---	---	---
Mansoy	---	---	---	26.8	---	---	---	---
Minnesota 166	37.4	---	---	---	---	---	---	---
Mukden	---	---	---	---	25.3	10.5	25.9	30.2
Pinpu	33.9	24.4	21.6	35.3	---	---	---	---
Soysota	38.7	21.2	17.9	---	---	---	---	---

* Low yields caused by the most severe drouth in the history of weather records at Ames.

counties on average soils. A second reason why most Iowa farmers seed general purpose soybeans rather than the hay varieties is that they prefer to grow their own seed or buy from their neighbors. In much of the state this would be impossible if the "hay varieties" were grown, as they mature too late to make seed. A third reason in favor of general purpose soybeans is that the grower often does not know until late in the season whether he will harvest the beans for hay or for seed. If the earlier general purpose varieties are grown, hay harvest comes a couple of weeks earlier than otherwise and at a time when conditions are usually more favorable for curing.

For planting with corn for hogging down, the common seed varieties such as Manchu, Dunfield, Illini, Mukden and Black Eyebrow are suggested. Yellow beans are thought by some growers to have an advantage over darker colors such as Black Eyebrow because they can be seen better by hogs. In general, varieties are wanted which will produce the largest yields of seed and will be approaching maturity about the time the corn is ready for the hogs.

For planting with corn for silage, the first requirement is ability to stand. Varieties also should be chosen which give the largest yields. Furthermore, the pods should be well filled and the leaves beginning to turn yellow about the time the corn is ready for silage. The general purpose varieties, Manchu, Illini, Dunfield, Black Eyebrow and Mukden may be used to advantage in the northern one-third of the state. Peking is the most satisfactory variety yet tested for the southern two-thirds of the state because of its later maturity and erect growth. Its erect growth permits satisfactory cutting with the corn binder.

TABLE 5. COMPARATIVE YIELDS OF VARIETIES TESTED FOR HAY.

(Yields in tons of air-dry hay per acre.)

Variety	1925	1926	1927	1929	1930	1931	1932
Arlington	2.55	2.03	1.88	---	---	---	---
Black Eyebrow	---	---	---	1.54	---	---	---
Columbia	2.52	---	---	---	---	---	---
Dunfield	2.60	2.78	2.32	1.62	1.56	2.52	3.06
Easy Cook	---	2.06	1.87	---	---	---	---
Habaro	---	---	---	1.38	1.30	1.43	2.78
Harbinsoy	---	---	---	1.41	---	---	---
Hong Kong	2.83	2.30	1.93	---	---	---	---
Hurrelbrink	2.41	---	---	---	---	---	---
Illini	---	---	---	1.62	1.72	1.90	3.29
Illinois 13-19	2.52	2.41	1.81	---	---	---	---
Illinois 13-181	2.85	---	---	---	---	---	---
Iochu	2.42	---	---	---	---	---	---
Laredo	---	---	1.75	---	---	---	---
Lexington	3.07	2.42	1.84	---	---	---	---
Manchu	2.59	2.46	1.97	1.47	1.50	1.80	3.07
Manchuria 13177	2.66	2.79	---	---	---	---	---
Mansoy	---	---	---	1.55	---	---	---
Merko	2.54	---	---	---	---	---	---
Midwest	2.17	1.98	1.32	---	---	---	---
Mikado	2 96	2.31	1.74	---	---	---	---
Morse	2.93	2.37	2.02	---	---	---	---
Mukden	---	---	---	1.64	1.59	1.97	2.91
Peking	2.57	2.37	1.76	---	---	---	---
Pinpu	---	---	---	1.60	---	---	---
Southern Prolific	2.59	---	---	---	---	---	---
Virginia	2.63	2.18	1.68	---	---	---	---
Wilson	2.76	2.29	1.68	---	---	---	---

Any of the later maturing varieties, however, such as Lexington, Virginia, Morse, Ebony, Wilson and others of similar maturity, can be used. For planting with corn to "sheep-down," any of the varieties recommended for silage will be satisfactory.

MANCHU

Manchu has been recognized as an outstanding variety since the first year of its test at the Iowa Station in 1916. It is now 17 years since this station introduced Manchu generally to Iowa farmers, and it continues to be the leading variety in the state. It is being grown for seed on 62 percent and for hay on 52 percent of the farms surveyed. During this period many varieties and hundreds of selections have been compared with Manchu, but none has been found to give consistently higher seed yields. It is fortunate that this excellent variety was among the early introductions of the United States Department of Agriculture from Manchuria. This good fortune has meant millions of dollars to American farmers because Manchu has been among the leading varieties in other northern states also.

About 5 to 10 percent of the seed of the early introduction of Manchu had brown seed scars or hilums. In 1925 the Station purified this variety by sorting out all the brown hilum seed before planting and distributed the increase under the name, "Black Hilum Manchu." Most of the Manchu soybean samples now exhibited in Iowa are pure for black hilum.

The different strains of Manchu vary in the time of maturity, although in all other plant characteristics they are apparently the same. A strain that can be depended upon to mature and yet makes full use of the growing season is believed to be preferable. Manchu is a medium-sized, oblong, yellow soybean with black hilum or seed scar. The seed rarely mottles enough to be objectionable and the plants stand fully ripe in the field for weeks without shattering.

For the 9-year period, 1916-24 (table 3, Bulletin 228), Manchu gave an average yield of 22.3 bushels per acre and outyielded all other varieties except Habaro, a variety much inferior in other respects.

ILLINI

Illini is a high yielding, yellow, non-shattering soybean of good quality, practically free from mottling. It was introduced a few years ago by the Illinois Agricultural Experiment Station and has become widely grown in the Corn Belt, particularly in Illinois. It has been popular in Iowa where tried. Of the farms surveyed 13 percent were growing it for seed and 11 percent for hay. It seems likely that the acreage of this variety will be extended further.

Illini has been compared with other varieties at Ames through a 5-year period, 1928-32, inclusive. During this period it outyielded Manchu in seed production 3 years out of the 5, while in hay production it yielded more each of the 4 years for which comparisons can be made (tables 4 and 5). As an average for the 5-year period it produced 26.6 bushels of seed and for the 4-year period 2.61 tons of hay per acre as compared with an average of 24.9 bushels of seed and 2.35 tons of hay per acre for Manchu, or an increase of 11 percent in both seed and hay (tables 2 and 3).

The advantage of Illini appears to lie in its ability to make full use of particularly favorable growing conditions. Thus, in the excellent years of 1928 and '32, Illini gave a yield of threshed beans which was 16 and 21 percent, respectively, more than Manchu (table 4). For the two medium years, 1929 and '31, and the very dry year of 1930, the two varieties yielded practically the same, with Manchu slightly better in 2 of the 3 years.

It is believed that Illini is a better seed variety for central and southern Iowa than Manchu. It is a few days later than Manchu, and while it has consistently matured seed at Ames and 50 miles farther north, the Iowa Station has been reluctant to recommend it generally for northern Iowa because of an occasional report that it has not matured. Failure to mature in those instances may have been because of local soil conditions or too late planting.

The Illini is an outstandingly good variety except for its tendency to lodge more than other high yielding sorts, although this fault is not sufficiently pronounced to be particularly objectionable. If the beans are allowed to become dry enough for

immediate threshing the stems straighten during the ripening process so that they are not difficult to cut with the binder or combine.

DUNFIELD

Dunfield is another excellent variety with non-shattering yellow seed that is seldom mottled to an appreciable extent. It was being grown for seed on 10 and for hay on 16 percent of the farms surveyed. As an average for the 10-year period, 1923-32, inclusive, it yielded 26.1 bushels per acre, or practically the same as Manchu. Annual yields for the two varieties since 1925, when Bulletin 228 was published, are shown in table 4 and averages for the 8-year period in table 2.

Dunfield usually ripens about the same time as Manchu, but sometimes a few days later. The two varieties are fairly similar in erectness of growth, although Dunfield yields somewhat more forage.

MUKDEN

Mukden, selected by the United States Department of Agriculture from one of its introductions, was named by the federal department for the city in Manchuria from which it originally came. It was tested coöperatively at Ames under the United States Department of Agriculture individual plant selection number 50523Q.

Mukden was first distributed to growers by the Iowa Station in the spring of 1932. Its short side branches, erectness of growth, non-lodging and non-shattering characteristics and earliness make it valuable to many growers. Ordinarily it is 2 to 5 days earlier than Manchu. The high yields of Manchu, Illini and Dunfield seem to be associated with the fact that they make full use of the growing season at Ames when planted about May 25. Since Mukden yields as high as other varieties at Ames under average conditions, with a shorter growing season it should have a distinct advantage in northern Iowa.

Although the non-lodging tendency of Mukden is noteworthy, particularly when the fineness of stem, high growth and high forage yields are considered, it has lodged occasionally at Ames with conditions favorable to heavy yields of for-

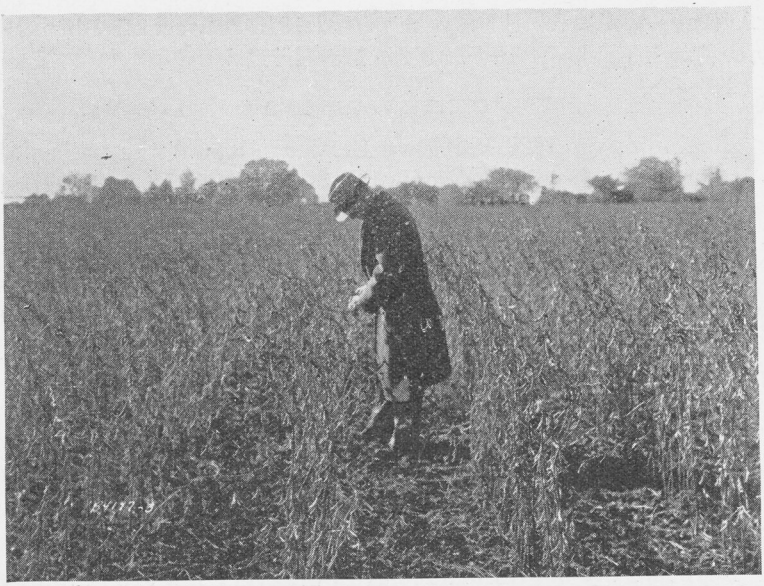

Fig. 6. A field of the new variety, Mukden, first distributed in 1932. This is the only selection increased at the Iowa Station as superior to varieties already available from the hundreds of selections tested. "Its short side branches, erectness of growth, non-lodging and non-shattering characteristics and earliness will recommend it to many growers."

age. It is, however, the most erect growing and non-lodging of all high yielding seed varieties that have been tested at the Iowa Station. It has yellow seed of excellent quality and has never mottled more than faintly during the 7 years it has been observed at Ames under a wide variety of growing conditions.

BLACK EYEBROW

Black Eyebrow, an excellent variety except for color of seed, and similar to Manchu in plant and yielding characteristics, was last included in the variety trials in 1928. It was then omitted because it yielded slightly less than Manchu and the seed color also seemed to make it somewhat less desirable. This variety was being grown for seed on 12 percent and for hay on 15 percent of the farms surveyed. As an average for the 4-year period 1925-28 Black Eyebrow yielded 29.4 bushels as compared with 30.3 bushels for Manchu. (See tables 2 and 4.)

Average yields for the 9-year period 1916-24 were 21.4 bushels for Black Eyebrow and 22.3 for Manchu.

OTHER VARIETIES

Beginning in 1928 the Iowa Station adopted the policy of limiting variety trials of soybeans to a few of the best named sorts, with the inclusion of as many new selections as possible. Furthermore, a selection or variety must demonstrate the characteristic of ripening in an average season in order to be included in the larger plat trials harvested with machinery. The fact that only one selection out of hundreds tested, Mukden, has been introduced by the Iowa Station emphasizes the value of varieties now generally grown in the state. The introduction of a new variety is not warranted unless it shows some definite points of superiority over those already available.

GROWING THE SOYBEAN CROP

Soybeans are not difficult to grow and very few crop failures are reported. Their requirements, however, are different from those of corn, oats, or other hay crops and the failure of inexperienced growers to allow for these differences often results in reduced yields. No other crop grown in Iowa has a wider latitude in dates between which specific operations may be performed or a greater range in the methods of performing the major steps in growing and harvesting the crop.

CONDITIONS ESSENTIAL TO SUCCESSFUL CULTURE

The most important factors in successful culture are:

1. Preparation of a good seedbed.
2. A thick stand.
3. Control of weeds.
4. Inoculation.

A Well-Prepared Seedbed

A well-prepared seedbed is essential to a good crop of soybeans. Growers seem generally agreed that plowing is desirable except, perhaps, where the crop succeeds itself. Early spring plowing, or fall plowing where that is feasible, permits killing most of the weeds before planting time. Thorough surface tillage to kill as many weeds as possible before planting

time reduces difficulty in weed control after the beans come up. The most successful growers prepare their soybean ground at the same time as their corn ground, but delay planting for 2 weeks to a month. This makes it possible to kill the weeds that have started with another discing before the final seedbed preparation. Early plowing and frequent discing are general in southern Iowa where it seems to save time as well as increase yields. In northern Iowa the larger yields from this practice indicate that it is more profitable than the more commonly used method there of plowing shortly before the final preparation for planting.

Soybeans planted in rows usually require less cultivation after planting than does corn. This is made possible in part by the later planting of the soybeans. Where the soybeans are drilled solidly it is more essential to have the weeds under control before planting, because cultivation after planting is not as effective as when they are planted in rows. Except for the delay between plowing and planting, preparation of the seedbed for soybeans is the same as for corn.

Fig. 7. A thoroughly prepared seedbed is one of the essentials to successful soybean production. Early spring plowing, or fall plowing, followed by repeated discing of the seedbed until planting time make it possible to germinate and kill most of the weed seed in the surface soil before the crop is put in the ground.

TABLE 6. THE RELATION OF EARLY PLOWING AND DELAYED PLANTING TO LABOR AND POWER USED IN GROWING SOYBEANS AND TO YIELDS OF SEED AND HAY.*

Days between plowing and planting	Number of fields	Hours per acre—growing			Yield per acre	
		Man	Horse	Tractor	Seed (bu.)	Hay (tons)
Southern Iowa:						
1– 7 days	8	4.62	6.70	1.95	20.3	1.5
8–14 days	9	4.86	13.46	1.45	21.0	2.3
15–30 days	28	4.09	9.10	1.60	23.6	2.5
31–60 days	19	5.32	16.25	1.11	22.1	2.2
Northern Iowa:						
1– 7 days	24	5.57	12.98	.98	19.9	1.9
8-14 days	6	5.56	14.32	.80	20.8	2.0
15–35 days	9	6.80	18.58	.99	27.2	2.0
Fall plowing	17	6.51	13.96	1.50	25.0	1.9

* Based on a study of 130 fields of soybeans selected in six representative counties in the two important soybean areas in Iowa.

Thick Planting Recommended

Thick planting of soybeans is recommended. When conditions are unfavorable for germination or when the soil becomes crusted before the plants are up, a thick stand helps break the crust and also permits some loss of plants without reducing the yield. Harrowing or tilling with the rotary hoe is desirable when the crop is planted in rows as well as when the crop is drilled solidly. Such cultivation may destroy from 15 to 25 percent of the plants so that thick planting is necessary if yields are to be maintained.

Tests continued through a 6-year period at Ames, summarized in table 7, shows that for soybeans grown in rows planting at 1-inch intervals not only increased the net yield of both seed and hay, but it also gave a finer quality of hay with fewer weeds than did thinner planting. It will be observed that for this thickness of planting approximately 1 bushel of seed per acre is required for 42-inch rows, while 1.8 bushels is about right for 21-inch rows.

When drilled solidly, planting at the rate of 2 bushels per acre gave the maximum yield of seed. Thick planting did not materially increase the yield of hay but it did give a finer

quality and a product much freer of weeds than was secured from the lower rates of planting. All things considered there are distinct advantages in using 2 bushels of seed per acre when the crop is drilled solidly or broadcast regardless of whether the crop is grown for seed or for hay. If seed prices are high there may be conditions, as for example when planting for green manure purposes, when less seed should be used.

Too deep seeding should be avoided. The ideal depth is 1½ to 2 inches. It is usually wise to plant no deeper than that even though the ground is dry at that depth. Deep planting increases the risk of a heavy dashing rain just after planting crusting the soil too much for the beans to come through. Such a crust must be broken if an adequate stand is to be obtained.

TABLE 7. EFFECT OF THICKNESS OF PLANTING ON NET YIELDS OF SEED* AND HAY AT AMES.†

Rate of seedings (bu. per A.)	Distance between seed in rows (inches)	Yield per acre		No. of plats averaged
		Seed (bu.)	Hay (tons)	
Planted in 21-inch rows				
3.66	½	24.5	2.55	24
1.83	1	26.0	2.67	24
0.91	2	21.3	1.99	29
Planted in 30-inch rows				
2.56	½	23.3	2.64	30
1.28	1	24.3	2.54	32
0.64	2	21.0	2.08	206
Planted in 42-inch rows				
1.83	½	22.1	2.22	24
0.91	1	22.2	2.24	26
0.46	2	17.5	1.75	31
Drilled solidly like small grain				
2.00	--	26.3	2.75	80
1.50	--	24.6	2.74	77
1.00	--	22.1	2.71	87
Broadcast‡				
2.00	--	22.9	---	13
1.50	--	19.9	---	13
1.00	--	17.4	---	13

* Yields after deducting for seed used.
† Summarized from Bulletin 228.
‡ Broadcast-beans were very weedy.

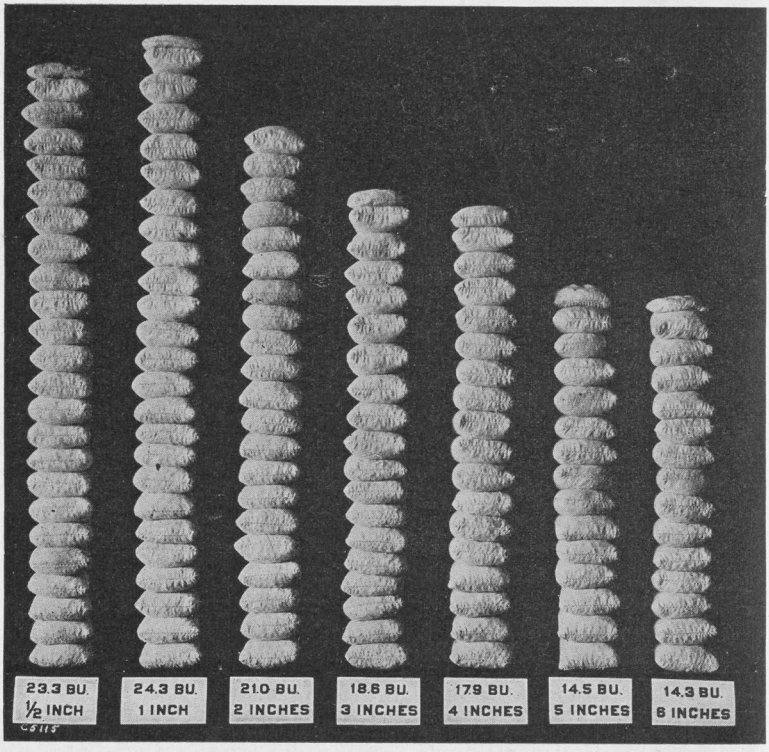

Fig. 8. Yield of beans obtained from different spacing of plants when grown in rows. The larger net yields of seed were obtained by spacing the plants approximately 1 inch apart. This thickness of planting requires approximately 1 bushel of seed per acre when the rows are 36 inches apart, 1¼ bushels for 30-inch rows and 1¾ bushels for 21-inch rows. The largest yields were obtained from the closer spaced rows.

Cultivation Usually Essential to Weed Control

Delayed planting of the soybean crop and thorough preparation of the seedbed in order to free the soil of weed seed has been mentioned as particularly desirable, if not essential to the satisfactory growing of soybeans, particularly when the crop is drilled solidly.

In southern Iowa, in a dry year, it is often possible with broadcast or solidly drilled soybeans to get along without cultivating if a thorough job has been done in freeing the seedbed of weeds before planting. In a sample of 90 fields observed in

1932, one-third was not cultivated at all, another third was cultivated once, 20 percent was cultivated twice, and 10 percent three times. The cultivation on slightly over one-half of the acreage in that area was with a rotary hoe and 45 percent with a harrow, while a small percentage was with a weeder. These operations were performed either just before the beans came through the ground, when they were in the six-leaf stage, or when they were about 8 inches high. It is often a shock to a new grower to see the devastation produced by the harrow or rotary hoe in cultivating a field of beans. If the stand is fairly thick the treatment will not seriously injure it, however, and will greatly reduce the weeds. The afternoon is reported to be the best time to cultivate since the plants are less likely to be snapped off than in the morning.

The reports of growers indicate that in northern Iowa cultivation after planting must be provided even if most of the weeds have been killed before planting. In that section it is very important to keep ahead of the weeds. The typical procedure is to harrow once just before the soybeans come up and then cultivate twice at intervals as required to check the weeds. This treatment varies with the conditions. Some fields need to be worked only once over, while others should be cultivated as many as five or six times. Harrowing cultivated rows the first time over is especially valuable in killing weeds in the rows. Only about 5 percent of the acreage was cultivated with the rotary hoe in northern Iowa, while 25 percent was worked with the harrow and 70 percent with cultivators.

TABLE 8. EFFECT OF DIFFERENT IMPLEMENTS USED IN CULTIVATING DRILLED SOYBEANS AT AMES.*

Implement used	Seed (bushels per acre)			Hay (tons per acre)		
				4-year average		
	No. plats averaged	7-year average	3-year average	Yield weed-free	Percentage weeds	No. plats averaged
None	24	20.71	21.13	1.88	27.8	13
Harrow	26	23.35	24.90	2.13	12.1	14
Weeder	26	25.62	26.29	2.11	11.9	13
Rotary hoe	9	----	24.55	1.94	16.9	9

* Summarized from Bulletin 228.

Fig. 9. Soybeans, whether planted in rows or drilled solidly, can be cultivated to advantage with the harrow, weeder, or rotary hoe. To keep the crop clean it is important that the cultivations be given just as the weed seedlings are breaking through the soil surface. The field may best be harrowed before the beans come up, later when the bean plants are 1 to 3 inches high, and lastly when 4 to 8 inches high.

The implement which may be expected to give the best results in cultivating beans drilled solidly will depend somewhat upon the character of the soil. The harrow probably has the widest range of usefulness, in that it can be used successfully on almost all kinds of soil. On soils which are mellow and not inclined to crust, the weeder is a splendid tool which, when used at the right time, will kill weeds effectively and with the minimum of damage to the bean plants. In comparisons at Ames, continued through a 7-year period, the harrow, weeder and rotary hoe were all considered to have given satisfactory results. The rotary hoe probably is particularly well suited to soils which are inclined to pack. The yields reported in table 8 probably would have been more favorable to the rotary hoe had the implement been moved over the field somewhat more rapidly than was possible with horses.

Inoculation Necessary to Satisfactory Results

It has been found that soybean bacteria are not naturally present in most Iowa soils. When nodules containing these bacteria are not formed on the roots of the soybean plant the yield secured may be greatly reduced and the protein content of the resulting crop markedly lowered.

The difference in both growth and yield because of the bacteria is likely to be most marked on soils low in nitrogen and organic matter. On such soils, inoculated beans have been observed to grow with relative vigor and have a dark green color, when, under the same conditions, uninoculated soybeans are spindling and yellow. On more fertile soils soybeans may yield satisfactorily even though the soybean bacteria are not present. When grown under such conditions, however, there probably is no crop which will more rapidly deplete the soil of its nitrogen, since the relatively large amount of nitrogen which the soybean plant requires for its growth must all come from the soil.

The inoculation of soybean seed is good crop insurance either when soybeans are being grown on a land for the first time, or when the grower is not sure that the soil contains an abundant supply of the proper bacteria as indicated by many large nodules on the roots of a previous soybean crop grown on the same land.

Commercial cultures of soybean bacteria may be purchased from most seed companies. These are easy to use by following directions which are always supplied with the cultures. Soil from a field where a well-inoculated crop has been previously grown may also be used with satisfactory results.

In using soil for inoculation, prepare a mixture with water having the consistency of thick cream. Three or four pints of soil are needed for each bushel of seed. Pour the mixture over the beans, stirring until every bean is well soiled. The soil can be taken from the field in the spring although the best results are had when the roots of well-inoculated beans are pulled in the fall and composted over winter with a little soil from the same field. Sift out the undecomposed material before the soil is used in the spring. Another method used among farmers is to apply dry soil taken from near the roots of well-inoculated bean plants to the moistened seed.

Fig. 10. Well developed nodules on soybean roots. Successful soybean production is largely dependent upon the activity of the soybean bacteria in the soil making available the air nitrogen to the growing plants. These bacteria are not naturally present in most Iowa soils, necessitating the inoculation of the seed when beans are planted on a piece of ground for the first time. Soil from a well-inoculated soybean field, or one of the commercial cultures may be used for inoculating.

ALTERNATIVE METHODS OF GROWING SOYBEANS

A study of 202 fields of soybeans in six representative counties in the two important soybean areas of Iowa shows that growers are using four distinctly different methods of growing the crop and that different methods predominate in different parts of the state. The methods being used are:

Growing solid:

1. Broadcast with an endgate seeder.
2. Drill solidly with a grain drill.

Growing in rows:

3. Plant with a corn planter.
4. Drill with a four-row drill.

The two solid planting methods are dominant in southern Iowa, while row planting is used almost exclusively in northern Iowa. About 95 percent of the southern Iowa acreage is planted solid while 90 percent of the northern Iowa acreage is planted in rows.

Not only are there marked differences in the planting operation and in the thickness of the stand obtained between solid and row planting, but there also are important differences in the methods used in seedbed preparation before planting, and in cultivation and weed control after planting.

Broadcasting and drilling solidly require a high proportion of the work before planting, while the four-row drill and corn planter methods both require a much larger share of the work after planting, in the form of cultivation.

TABLE 9. RELATIVE IMPORTANCE OF FOUR CHIEF METHODS OF GROWING SOYBEANS IN IOWA.*

Method of growing crop	Percentage of farmers using method	
	Northern Iowa	Southern Iowa
Broadcasting—solid	--	7
Grain drill—solid	10	88
Corn planter	55	5
Four-row drill (21 to 28″ rows)	35	--
Number of fields in sample	80	122

* Based on a study of soybean fields selected from six representative counties in the two important soybean areas in Iowa.

Fig. 11. Soybeans drilled solidly at the rate of 2 bushels of seed per acre have given the largest yields in planting comparisons at Ames. Eighty-eight percent of the southern Iowa crop is seeded in this way, while in northern Iowa almost all of the crop is grown in cultivated rows 21 to 42 inches apart.

It will be observed from table 9 that the first of these four methods, broadcasting, is almost never used in northern Iowa and is used by less than 10 percent of the growers in southern Iowa. Occasionally if there is a shortage of labor, which makes it important to save the time usually spent in plowing, farmers in southern Iowa seem to find broadcasting desirable. In southern Iowa soybeans are seldom planted with a corn planter either, so that the choice of a large majority of the farmers there is solid planting with the grain drill. The advantage in seeding solidly, as compared with row planting, in decreasing soil washing may be a factor.

In northern Iowa it is much less certain which method of the three commonly used is best suited to each case.

Table 7 shows that under experimental conditions at Ames drilling solidly has given as good net yields of both seed and hay as planting in 21-inch rows, nearly 2 bushels per acre more than in 30-inch rows and 4 bushels per acre more than in 42-inch rows. Hay yields show a similar advantage in favor of narrow rows or solid drilling. In addition to the yield differences in favor of solid drilling, it was found that less labor and power were needed to grow the crop that way and that it was

easier to harvest, particularly when beans were harvested as hay. The chief disadvantages of solid drilling are the scarcity of grain drills in much of the state and the difficulty in controlling weeds. This latter obstacle was overcome at the Station by planting thickly and by repeated, well-timed cultivation with a harrow or rotary hoe.

In spite of these findings under the rather typical soil, topographic and climatic conditions at Ames, northern Iowa farmers appear to find the method of planting or drilling in cultivated rows better suited to their conditions. Table 9 shows only 10 percent of the farmers in that part of the state drilled solidly with a grain drill, and these used the crop chiefly for hay.

Fifty-five percent of the bean growers in this area used a corn planter and 35 percent drilled in rows with a regular bean and beet drill, or with an old grain drill adjusted to plant four rows of beans in the same fashion as the beet drill. This home-made outfit for drilling beans in rows has proved rather popular in many parts of northern Iowa. It usually consists of a 7-foot grain drill with two holes out of each three stopped up, leaving the rows 21 inches apart. By removing the back shovels

Fig. 12. Drilled beans (left) outyielded broadcast plantings (right) approximately 5 bushels per acre as an average of over 40 comparisons during a 5-year period at Ames. Broadcast beans germinate slowly, poorly and ununiformly, give poorer stands, and cannot be kept as free from weeds as plantings drilled solidly with the grain drill.

on a one or two-row corn cultivator the work of cultivation may be done at the same speed as in cultivating corn. This outfit is equivalent to the regular bean and beet drill and cultivator.

The outstanding difference between the two chief methods of planting and growing beans used in northern Iowa is that the corn planter method is an emergency method, while the four-row drill method is used by those who plan to grow soybeans rather regularly in their crop rotation. Many farmers will never plant a sufficient acreage to pay for any considerable expenditure for special equipment, and for them the corn planter method is often the best. The high proportion of soybeans put in with a corn planter in northern Iowa is some indication of the extent to which soybeans are an emergency crop in that part of the state. Where an old wheat drill is available, where acreages are large, or where neighbors can afford to own the necessary equipment jointly, the four-row drilling method, or solid drilling, is being adopted.

As was pointed out in the early part of this publication, soybeans have been grown much more extensively and through a longer period in southern Iowa than in east central and northeastern Iowa. The general practice of drilling soybeans, almost to the exclusion of all other methods, prevails where the beans have been grown longest and most extensively. In southern Iowa farmers are accustomed to the use of a drill in seeding winter wheat, and drills are to be found on many of the farms there. Men growing soybeans for the first time are likely to seed in wide rows in order that they can cultivate the crop with their usual equipment. It seems altogether possible that as beans become more thoroughly established in the northern and central Iowa sections the practice of drilling solidly or in narrow cultivated rows may become more common.

Labor and Power Used in Growing Soybeans up to Harvest Time

In northern Iowa the four-row drill method (21 or 28-inch rows) distinctly outranks the corn planter method in efficiency, requiring on an average only two-thirds as much man labor and four-fifths as much power. Indeed, only 4.71 man hours per acre were used up until harvest time when the beans were put in with a four-row drill, while 6.99 hours were required when the corn planter was used.

TABLE 10. LABOR AND POWER USED IN GROWING SOYBEANS UP TO HARVEST BY THE FOUR METHODS COMMONLY USED IN IOWA.*

Method of growing	Northern Iowa				Southern Iowa			
	Hours per acre				Hours per acre			
	No. fields	Man	Horse	Tractor	No. fields	Man	Horse	Tractor
1. Broadcast	---	---	---	---	9	3.74	12.06	.49
2. Drill—solid	8	4.14	11.69	.76	107	4.10	9.70	.49
3. Corn planter	44	6.99	18.18	.78	6	5.10	9.40	.89
4. Four-row drill (21 to 28″ rows)	28	4.71	7.61	1.93	---	---	---	---
Average	80	5.91	13.90	1.16	122	4.11	9.88	1.37

*Data from same source as for table 9.

While the four-row drill is particularly adapted for the production of soybeans, it also is a satisfactory method for raising a hay crop in that section. It need take no more time or power than drilling solidly, and beans put in by that method do have the advantage that they can be cultivated if it is necessary to kill the weeds. Drilling solidly gives a somewhat finer quality of hay than drilling in rows; it also leaves a smoother and evener surface on which to operate the haying machinery. There is less trouble in cutting, and the hay is freer from soil and cures better on the uniformly distributed stubble. If the field is to be drilled solidly for hay, it is essential that it be weed-free and well prepared before planting.

TABLE 11. RELATION OF THE METHOD OF GROWING SOYBEANS UP TO HARVEST TO THE YIELD OF BEANS AND HAY.*

Method of growing	Yield per acre							
	Northern Iowa				Southern Iowa			
	Beans		Hay		Beans		Hay	
	No. fields	Bushels	No. fields	Tons	No. fields	Bushels	No. fields	Tons
1. Broadcast	--	---	--	--	5	17.0	4	1.9
2. Drill—solid	2	17.7	6	1.9	54	22.8	53	2.4
3. Corn planter	18	19.7	26	1.8	4	19.3	2	1.5
4. Four-row drill (21 to 28″ rows)	17	25.2	11	2.3	--	---	--	--
Average	37	22.1	43	1.9	63	22.1	59	2.3

* Data from same source as table 9.

Not enough fields of broadcast seeding were obtained to make accurate comparisons. Table 10 shows, however, that in southern Iowa broadcast beans require about 10 percent less labor and 20 percent less power than those drilled solidly with a grain drill. But yields from broadcast fields are so low, probably because of poorer stands and less uniform germination, that this method is relatively unsatisfactory compared with the solid-drilling method. (See table 11.) This is in accord with the results secured at Ames from comparative plantings under controlled conditions, in which case yields were approximately 4 bushels of seed and ¼ ton of hay higher per acre on drilled than on broadcast plantings.

Drilling Gives Higher Yields at Less Cost

In northern Iowa soybeans planted with a four-row drill in 21 or 28-inch rows yielded 25.2 bushels of seed, or 2.3 tons of hay, while those planted with a corn planter yielded 19.7 bushels, or 1.8 tons. The number of fields drilled solidly was insufficient to give dependable yield figures. On clean ground there is good reason to believe that yields of solidly drilled beans will be as high as from beans drilled in rows.

In southern Iowa drilling solidly with a grain drill produced

Fig. 13. With the soybeans drilled solidly in planting comparisons at Ames, the cultivated beans produced 24.5 bushels per acre on the average for 7 years, as compared with 20.7 bushels when the crop was not cultivated.

Fig. 14. Soybean plantings made at Ames at weekly intervals from April 19 to July 5, for the 6-year period, 1919 to 1924, showed relatively small yield differences, either of seed or of hay, from plantings made at the earliest date to and including those made about June 1. All things considered, planting the last week of May or first few days of June is most desirable.

22.8 bushels of seed and 2.4 tons of hay per acre as compared with 17.0 bushels and 1.9 tons for broadcasting, and 19.3 bushels and 1.5 tons for the corn planter method. These yields are in accord with what might be expected, though the number of farms from which they were obtained was too few to be sure that this difference would be repeated.

The four-row drill is greatly superior to the corn planter. In some cases it either saves labor and power or it increases yields. In others it accomplishes both these results. These are items of no little importance to soybean producers of northern Iowa.

In the 72 field samples reported in table 12, with the price conditions assumed, in northern Iowa the four-row drill method produced $3.23 greater return per acre of seed and $4.43 greater return per acre of hay than where the soybeans were planted with a corn planter. In southern Iowa a similar comparison of drilling solidly with planting by means of a corn planter shows that solid drilling produced an average of $3.21 greater returns per acre than where the corn planter method was used.

Which is the best of these four methods of planting depends largely on the soil, the difficulty of controlling weeds, the machinery available, the acreage, and the question of whether the beans are being grown to fill a temporary emergency or as a regular part of the rotation.

TABLE 12. ECONOMIC ADVANTAGE PER ACRE OF THE FOUR-ROW DRILLING COMPARED WITH THE CORN PLANTER METHOD.*

	(Northern Iowa) Advantage of 4-row drill over corn planter	
	Beans	Hay
Savings on labor and power if four-row drill is used instead of corn planter	$ .41	$ .41
Value of increased yield	$3.30	$4.50
Total	$3.71	$4.91
Less .8 bushel more seed required by four-row drill method	$ .48	$ .48
Per acre advantage of four-row drill method over corn planter method	$3.23	$4.43

* The physical basis for this table is given in tables 10 and 11 in which the results are for labor at 25c per hour, horse labor at 8c per hour, tractor time at 85c per hour, soybeans at 60c a bushel and soybean hay at $9 a ton. Also 1 bushel of seed was used in the corn planter and 1.8 bushels in the drill.

Equipment, the variable factor in this table, must be paid for out of the greater returns the four-row drill method gives. Varying efficiency of physical factors on individual farms and changing prices will, of course, materially affect the results shown in this table, in some cases perhaps completely reversing their significance.

Most southern Iowa farmers can obtain a wheat drill in their own neighborhood. In such cases using the solid-drilling method will usually pay.

In northern Iowa if a drill is not available the corn planter can be made to serve to advantage for small acreages, or in a temporary emergency. Some farmers are obtaining about the same results as with the four-row method by double rowing with the corn planter. This, however, involves twice the labor and power cost of planting and producers are often loath to risk this additional investment on an emergency crop.

HARVESTING SOYBEANS AS SEED

Three methods of harvesting soybeans for seed are important in Iowa. About 80 percent is harvested with a binder, shocked and then threshed. The difficulty encountered with this method is that unless the separator is adjusted for threshing beans, a

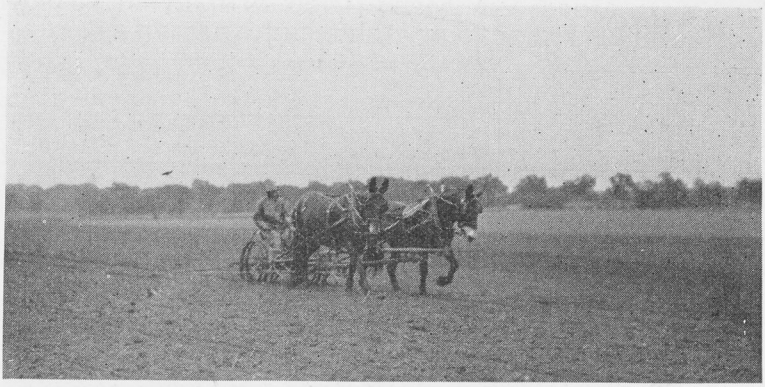

Fig. 15. Planting soybeans with a corn planter is looked upon as an emergency method. In northern Iowa, where the crop has not entered largely into the regular rotations, the corn planter is used to put in 55 percent of the acreage; planting in narrow rows with a drill is used for 35 percent of the acreage, and 10 percent is drilled solidly. In southern Iowa where the crop has been established longer, 88 percent of the crop is drilled solidly.

rather high proportion may be cracked. Recent studies show that from 10 to 12 percent of the area in soybeans in the more important growing districts are harvested by means of a combine. This method is well liked and is growing in popularity. A third method, which is used chiefly in southern Iowa, is to mow, rake and thresh. The particular advantage of this method is that it saves the binder and cash outlay for twine, although it increases the amount of labor, often reduces the quality of the seed obtained and in some cases an additional charge is made of about a cent a bushel for threshing the unbound beans.

Table 13 shows the importance of these three methods in northern and southern Iowa and indicates the differences in labor and power used per acre. Each of the three methods takes approximately the same tractor time, on the average, so that the chief differences are in the amounts of man and horse labor and machinery, and in the cash outlays. Combining requires an average of 2.44 hours of man labor per acre. Binding, shocking and threshing uses 6.81 hours, while the mow-rake-thresh method requires 9.34 hours. This means that combining can be done with only about one-third as much labor as the bind-shock-thresh method, or one-fourth as much time

TABLE 13. LABOR AND POWER USED IN HARVESTING SOYBEANS FOR SEED BY THREE CHIEF METHODS.*

Method used	Hours per acre			Percentage of farmers using method	
	Man	Horse	Tractor	Northern Iowa	Southern Iowa
Bind—shock—thresh	6.81	8.29	0.81	87	73
Mow—rake—thresh	9.34	10.19	0.88	--	16
Combine	2.44	2.20	0.81	13	11
Average	6.54	7.75	0.82		

* Based on a study of 101 fields of soybeans selected from six representative counties in the more important soybean areas of Iowa.

as the mow-rake-thresh method. Horse labor requirements are even more favorable to combining than are man labor requirements as table 13 shows. While combining saves a great deal of labor and reduces the loss from shattering to a minimum, it has the disadvantage, of course, that the straw cannot readily be saved for use at the barn.

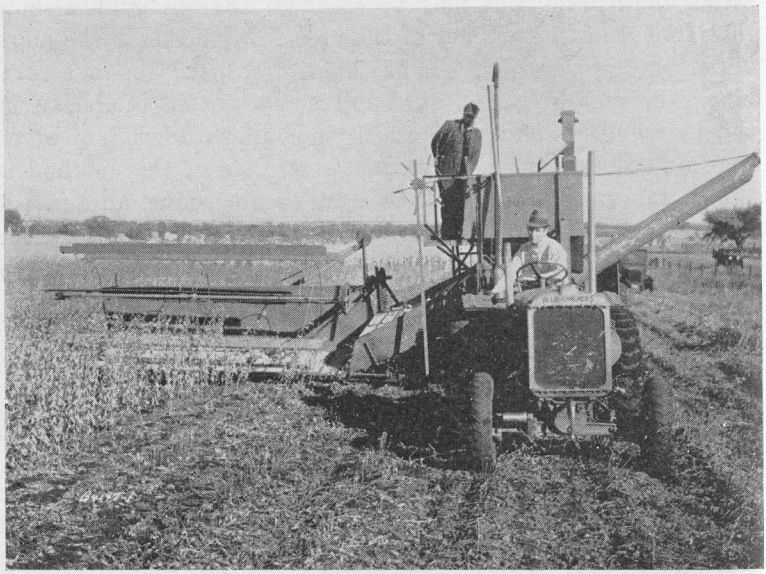

Fig. 16. The soybean crop is ideally suited to harvest with the combine. About 10 percent of the crop is now harvested with the combine, and this method is growing in popularity, due no doubt to the smaller amount of labor required, lower total cost, and less waste of seed.

A study of the cash outlay required when the combine method is used, as compared with that required by the bind-shock-thresh method, indicates that the combine requires very little more cash outlay than the more common method. If a binder is used, twine normally will have to be purchased. This outlay plus the threshing charge, which is usually on a bushel basis, amounts to only a few cents less per acre than the per acre charge usually made by combine operators.

Table 14 shows, with 1932 prices (first column), and at two other price levels, the economic advantage of the combine over the bind-shock-thresh method.

TABLE 14. ECONOMIC ADVANTAGE OF THE COMBINE METHOD OF HARVESTING SOYBEANS OVER THE BIND—SHOCK—THRESH METHOD ON A PER ACRE BASIS UNDER THREE POSSIBLE PRICE SITUATIONS.

	1932 Prices & costs	Other assumed price situations	
	Labor at 15c per hour*	Labor at 25c per hour†	Labor at 35c per hour‡
Saving of labor and horse labor if combine is used	$1.02	$1.58	$2.14
Twine saved	.28	.35	.42
Total savings	$1.30	$1.93	$2.56
Combine charge	$1.75	$2.25	$2.75
Less threshing charge	1.32	1.77	2.21
Excess paid for use of combine	.43	.48	.54
Per acre savings of the combine method over the bind—shock—thresh method	$ .87	$1.45	$2.02

* Labor at 15c, horse labor at 6c, twine at 8c (3½ lbs. per acre), combine charge at $1.75 per acre and threshing charge at 6c per bushel.

† Labor at 25c, horse labor at 8c, twine at 10c, combine charge at $2.25 per acre and threshing charge at 8c per bushel.

‡ Labor at 35c, horse labor at 10c, twine at 12c, combine at $2.75 per acre and threshing charge at 10c per bushel.

With labor at 15 cents an hour and other prices at about the 1932 level, the savings of the combine over the bind-shock-thresh method, indicates that the combine requires very little age yield. If the labor is figured at 25 cents an hour and other costs in proportion, the advantage of the combine rises to $1.45

Fig. 17. Of that part of the Iowa bean crop cut for seed, 80 percent is harvested with the grain binder. The binder is also used to harvest a considerable part of the acreage harvested as hay—in some important sections as much as 60 percent.

per acre. If labor is figured at 35 cents per hour, this advantage is $2.02 per acre.

Evidently, the higher the price of labor the greater is the advantage of the combine. Also the higher the yield the greater is its advantage, while the lower the yield the less is its advantage as compared with the threshing method. Many farmers, particularly in northern Iowa, have been able to make considerable savings in the bind-shock-thresh method by threshing without shocking the bundles. Where this is possible the advantage of the combine is reduced by this saving of labor.

The savings which the combine make are chiefly in labor and power. If the labor and power available cannot be used in other ways to bring in a money return, saving them will not appear worth even 15 cents an hour to many farmers.

It can be said that the soybean is more ideally suited to the combine method of harvesting than any other crop since there is a longer period in which the harvesting can be done. Soybean varieties now generally grown are not subject to serious shattering and may be allowed to stand in the field until the beans are thoroughly dry and ready for the bag or bin. The best quality of seed can be obtained if the beans are allowed to become thoroughly ripe on the standing stalks before harvest.

HARVESTING SOYBEANS AS HAY

Iowa farmers have had more difficulty in harvesting soybeans for hay than with any other operation connected with soybean culture. This difficulty is not encountered where the yield is moderate, but if the yield is excessively heavy it is always hard to tell which will be the best method to cure and put up soybean hay. The best method to follow depends upon two elements which are:

1. The labor, power and cash outlays required by alternative methods.
2. The effect upon the quality of the hay, especially the loss from shattering of leaves.

A comparison between the labor and power used by the chief alternative methods is made below, but the effect on the quality of hay and the loss from leaf shattering must be determined largely by the individual farmer.

Four methods of putting up soybean hay are common in Iowa. These are:

1. Mow, rake, cock by hand, load by hand and unload with a power fork.
2. Mow, rake, cock with a rake, load by hand and unload with a power fork.
3. Mow, cure in the swath or windrow, load with a hayloader and put up with a power fork.
4. Cut with a binder, shock, load by hand and unload with slings.

Hand cocking and the method of curing in the swath or windrow, are used in all parts of the state. The second method, in which the hay is cocked with a rake, is used chiefly in southern Iowa, while the fourth method, cutting with the binder, is used chiefly in northern Iowa. Cocking by hand ordinarily produces an excellent quality of hay at a high expense for labor. Cocking with a rake ordinarily produces better quality hay than if it is put up with a hayloader, but not so good as that cocked by hand.

If the hayloader method is used, the loss of leaves is likely to be heavy. It is advisable to work only mornings when the leaves are somewhat damp if this method is used, and the hayloader should be rigged with an apron which will save the leaves.

This precaution also will prevent heavy losses of beans. If adequate haying machinery and plenty of labor and power are available to handle the hay while slightly damp, the third method may be used with entirely satisfactory results. Cutting soybean hay with a binder has been found the most satisfactory method in northern Iowa by producers who have had limited experience with the crop. It is most dependable in producing a good quality of hay with little shattering. When this method is used the shocks should be left in the field for 10 days to 2 weeks to cure the crop thoroughly before it is taken to the barn, and it may be left considerably longer. Soybean hay stands a surprising amount of rain while in the shock without any considerable reduction in quality. A four-bundle shock is most commonly made after the binder.

When the yield of hay is very heavy a binder may give considerable trouble since the soybeans become so tangled that the divider board does not separate the standing plants from those already cut. Some experienced growers use an extension divider board and lifter guards, while others use a corn binder. With heavy hay a power binder will be found more satisfactory than a horse-drawn machine. If soybeans are drilled in rows starting on the outside of the field and spiraling in, the ridges will not interfere with the smooth operation of the binder at harvest time.

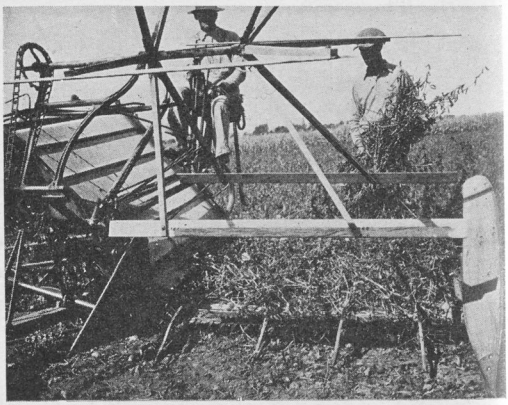

Fig. 18. Grain saver guards on the binder have been found helpful in harvesting the crop. Beans sometimes lodge badly, depending upon the season and the soil. Also, most varieties have long side branches and even when the main stems are erect the saver guards lift the branches so that cleaner cutting is possible.

Table 15 shows that the hayloader method requires consid-

TABLE 15. LABOR AND POWER USED TO PUT UP SOYBEAN HAY BY FOUR CHIEF METHODS.*

Methods used	No. fields	Hours per ton			Percentage farmers using method	
		Man	Horse	Tractor	Northern Iowa	Southern Iowa
1. Mow, rake, *cock by hand, load by hand,* unload power	27	5.89	5.11	--	14	42
2. Mow, rake, *cock with rake, load by hand,* unload power	18	4.27	5.15	--	--	34
3. Mow, *cure in swath or windrow, hay loader,* power fork	21	3.24	4.51	.10	22	24
4. *Cut with binder,* shock, load by hand, unload with slings	24	4.25	5.16	.10	64	--
Average of all methods		4.62	4.91	.07		

* Same source as for tables 10 and 13, but in this case the sample consists of 90 fields of soybean hay. The average yield per acre was 2.2 tons of hay.

erably less time and power than any of the others. Indeed, it utilizes 3.24 man hours per ton as against 5.89 man hours per ton for handcocking, and 4.27 hours per ton when the hay is cocked with a rake. The third method in table 15, that of curing in the swath or windrow and putting up with a hayloader, requires about 75 percent as much time as methods 2 and 4 and only about 55 percent as much as method 1.

The economic advantages of these four methods vary with the cost of labor and power, on the one hand, and the quality and quantity of the hay saved, on the other hand. With labor figured at 15 cents per hour, method 3 saves 36 cents per ton in the cost of putting up hay as compared with method 1; it saves 12 cents per ton as compared with method 4. Proportionately higher savings are found if labor and other costs are figured at a higher value.

These savings, however, must be sufficient to more than make up for possible reductions in the quality of hay if the more rapid methods are to prove satisfactory. For example, method

TABLE 16. ECONOMIC ADVANTAGES OF CURING SOYBEAN HAY IN THE SWATH OR WINDROW AND PUTTING UP WITH THE HAYLOADER OVER THE THREE OTHER METHODS OF HARVESTING SOYBEAN HAY.

Price situation	1932	Other situations	
Assumed cost rates:			
Labor per hour	$ .15	$ .25	$ .35
Horse work per hour	.06	.08	.10
Tractor per hour	.70	.85	1.00
Twine per pound	.08	.10	.12
Advantage of method 3: Mow, *cure in the swath or windrow, hayloader* and power fork over following method:	Savings (dollars per ton)*	Savings (dollars per ton)*	Savings (dollars per ton)*
1. Mow, rake, *cock by hand, load by hand*, unload with power fork	$ .36	$ .63	$ .89
2. Mow, rake, *cock with rake, load by hand*, unload with power fork	.12	.23	.32
4. *Cut with binder*, shock, load by hand, unload with slings	.32	.47	.62

* Based on data from table 15 and on an average yield of 2.2 tons of hay per acre.

Fig. 19. When the crop is harvested with the binder for seed, being cut soon after the leaves have fallen, it is cured in much the same manner as small grain though the shocks are smaller. When cutting is delayed until the seed has dried and cured in the pods, the crop can be threshed immediately without shocking. The best quality of seed is obtained when the beans are allowed to dry and cure on the standing plants.

3 will save 36 cents worth of labor and power per ton over method 1, but on hay valued at $6 a ton, 36 cents is not much to cover any loss in quality. Indeed, the saving will pay for only 120 pounds of hay. If there is a surplus of labor on the farm the slower methods will look even more desirable.

THE TIME ELEMENT IN SOYBEAN PRODUCTION

In the farm survey soybeans were found to have been planted in southern Iowa as early as May 10 and as late as June 25 with good results, although the best period seemed to be from May 15 to June 5. In the northern part of the state the practice is to plant in a more limited period lying rather close to the favored period from May 25 to June 5.

Plantings made at Ames at weekly periods from April 19 to July 5, during a 6-year period, showed relatively small yield differences of either seed or hay from plantings made from the

TABLE 17. TIME OF PLANTING AND HARVESTING SOYBEANS.*

Date of performing operation	Number of fields			
	For seed		For hay	
	Northern Iowa	Southern Iowa	Northern Iowa	Southern Iowa
Planting soybeans:				
May 5-15	1	9	1	7
May 16-25	6	19	9	20
May 26-June 5	23	18	24	16
June 6-15	3	5	1	5
June 16-25	2	5	4	4
June 26-July 5	1	2	2	1
July 6-15	--	1	--	1
Cutting soybeans				
Aug. 10-20	--	--	3	2
Aug. 21-31	--	--	7	10
Sept. 1-10	--	3	15	17
Sept. 11-20	--	6	7	9
Sept. 21-30	2	7	4	6
Oct. 1-10	13	23	--	3
Oct. 11-20	8	12	--	1
Oct. 21-31	1	--	--	--
Nov. 11-20	3	6	--	--
Nov. 21-30	1	--	--	--

* Based on a study of 180 fields of soybeans selected in six representative counties in the two important soybean areas in Iowa.

earliest date, to and including those made about June 1. With satisfactory moisture conditions a fair crop of hay may be expected from a planting made as late as July 1. Delay of a week in the planting date usually will delay harvest about 3½ days.

Soybeans may be harvested for seed by cutting and shocking as soon as the pods are matured and before the leaves have entirely fallen, or the crop may be allowed to stand until late in the fall, after the seeds have thoroughly cured and dried in the pods. In the latter case it may be combined or threshed immediately after cutting without shocking.

There also is a considerable period during which the crop may be harvested as hay. In fact, there is a wide difference in the results obtained by farmers and in experimental tests as to the best stage of maturity at which to cut hay. This may range from soon after full bloom until the pods are full and the leaves yellowing. Considering yield, total digestible nutrients and palatability, however, the Iowa Experiment Station favors cutting when the pods are from one-half to three-fourths full.

It is evident from the preceding discussion that the individual grower can arrange to plant and harvest the soybean crop at times which best fit into other activities.

The operation in soybean production requiring the greatest exactness of time, is *cultivation*. Drilled soybeans, particularly, should be cultivated whenever any considerable amount of weed seed has sprouted. Cultivation with the harrow, weeder or rotary hoe, to be effective, must be done at just the right time.

The Labor Distribution on Selected Farms

Figure 20 shows the labor distribution and other pertinent facts regarding the soybean crop on two southern and three northern Iowa farms. A study of these cases suggests the labor requirements of the crop during the cropping year.

In southern Iowa, the labor used in growing soybeans is applied during the period April 15 to July 15. In that period each 10 acres of beans require something like one man's time for about four 10-hour days. If these 10 acres are to be harvested for seed, 6½ days more are needed in the seed harvesting period which extends from Sept. 15 to Dec. 1. Thus 10½

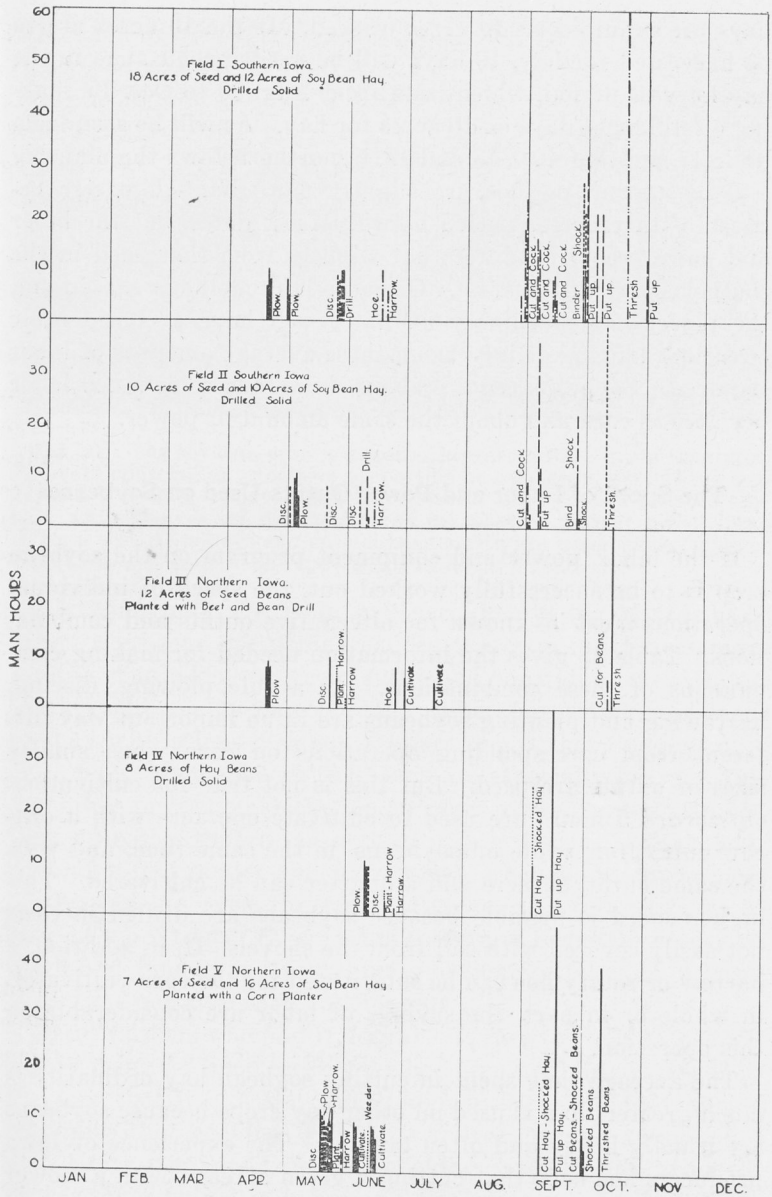

Fig. 20. Labor distribution on five selected farms.

days are required on 10 acres of seed. If the 10 acres are to be harvested for hay, 10 days will be needed some time in the hay harvest period, which lasts from Aug. 20 to Oct. 15, making a total of 14 days on 10 acres for hay. As will be seen from table 17 and tables 10, 13 and 15, in northern Iowa the planting and harvesting periods are slightly more limited, partly because of the shorter period between frost dates, but the labor and power required differs but slightly from that used in the southern part of the state. Of course the methods chosen and the power and machinery available will have a considerable effect in reducing or increasing these average amounts of labor required. Soybeans require about three-fourths as much labor per acre as corn and about the same amount of power.

The Speed of Labor and Power Outfits Used on Soybeans

If the labor, power and equipment program on the soybean crop is to be successfully worked out, the speed of individual operations must be known for alternative outfits and combinations. Table 18 gives the information needed for making comparisons of these combinations. As a rule plowing, discing, harrowing and planting soybeans are in no important way different from corresponding operations on corn when similar sizes of outfits are used. But this is not true for cultivation. On corn, 1.5 hours are used to cultivate one acre with a one-row cultivator, while on soybeans, in the same time, and with the same outfit, an acre and a quarter can be cultivated. This higher speed is possible because soybeans are drilled in rows not easily covered with soil from the shovels. If, in addition, a harrow or rotary hoe can be substituted for the corn cultivator, in whole or in part, the savings of labor are considerable on this operation.

The average time spent in cutting soybean hay ordinarily is much greater than is used on other hay crops because soybeans are usually heavy and often tangled. The experience of Iowa producers has been that cutting a given acreage with a mower takes fully 25 percent more time than a similar acreage of mixed hay. Table 18 shows that the usual speed with a 6-foot mower is 1.21 hours per acre, while the same outfit will nor-

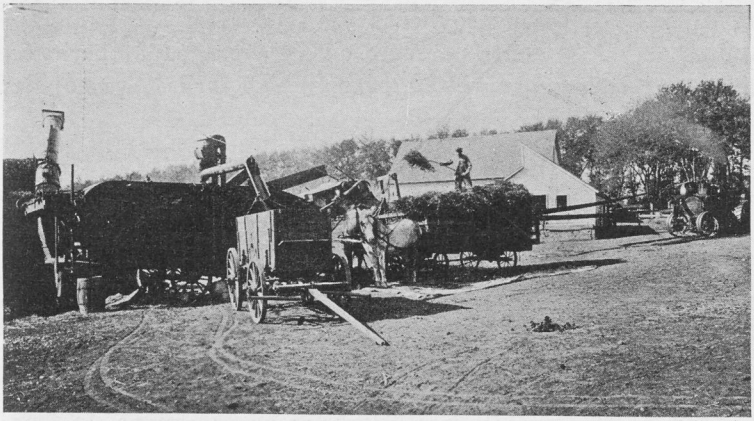

Fig. 21. The soybean crop is usually threshed with a grain separator. To avoid splitting an excessive proportion of the beans, part of the concaves are usually removed and the speed of the cylinder reduced one-half, while the rest of the machine is operated at normal speed. Two or three special pulleys and special bean sieves are necessary. Thresher companies can furnish the special soybean equipment.

mally take only .97 hour per acre in cutting Mixed hay.[3] When the beans are drilled solidly the crop can be cut more rapidly than when grown in cultivated rows since there is less trouble with the mower choking. When harvesting row beans for hay with a binder, many farmers report that they cut only one row at a time where the beans are especially heavy. This and other factors make the binder much slower on soybean hay than on oats. Indeed, an acre of oats is cut in .7 of an hour with an 8-foot binder and four horses, whereas, to cut an acre of soybean hay with the same outfit, on an average, takes 60 percent more time. Even to cut an acre of beans for seed with the 8-foot binder and four horses ordinarily takes 50 percent more time per acre than cutting oats.

Those farmers who find it desirable to save the quality of their hay by using the hand cocking method need not be discouraged by the fact that it is a slow and tedious task. But they should recognize that cocking by hand requires, on an average, 4.33 man hours per acre whereas shocking soybean hay after the binder takes only 1.76 hours and also gives an excellent quali-

[3] Figures showing the speed of operations on other crops are taken from Iowa Bulletin 264 and unpublished tables from the Webster County Farm Record Route.

ty of hay. Shocking soybeans for seed after the binder requires only 1.49 hours per acre on an average. Experienced growers recommend shocking beans with a fork. As compared

TABLE 18. LABOR AND POWER USED PER ACRE FOR MAJOR OPERATIONS ON SOYBEANS.

Growing soybeans	Number of observations	Hours per acre for outfit			Acres per 10-hour day average
		Average	Low*	High*	
Plowing:					
2-14″—4 horses	30	2.00	1.75	2.40	5.0
2-14″—tractor	50	1.35	1.10	1.55	7.4
3-14″—tractor	15	1.00	.80	1.17	10.0
Single discing:					
8′—4 horses	18	.53	.42	.67	19.0
10′—5 horses	9	.45	.40	.53	22.0
Double discing:					
7′—tandem tractor	24	.42	.32	.53	24.0
8′—tandem tractor	21	.39	.30	.52	26.0
Harrowing:					
16′—4 horses	11	.35	.30	.38	29.0
18′—4 horses	13	.32	.27	.40	31.0
20′—4 horses	28	.20	.20	.33	36.0
20′—tractor	8	.18	.15	.20	56.0
Broadcasting:					
Endgate seeder—2 horses	7	.21	.15	.29	48.0
Drilling:					
7′—4 horses	45	.74	.53	.90	13.5
4-row—2 horses	12	.62	.52	.71	16.1
Planting—Corn planter:					
2-row 32″—2 horses	7	.76	.67	.86	13.2
2-row 42″—2 horses	15	.67	.60	.80	14.9
Rotary hoe:					
7′—2 horses	13	.63	.50	.78	15.9
2-7′—tractor	6	.33	.30	.36	30.3
Cultivating—Corn cultivator:					
1-row 32″—2 horses	6	1.36	1.15	1.50	7.3
1-row 42″—2 horses	11	1.20	1.03	1.35	8.3
2-row 84″—3 horses	5	.65	.60	.75	15.4
Cultivating — Bean cultivator:					
4-row 28″—2 horses	5	.60	.51	.68	16.7
4-row 21″—3 horses (adjusted 2-row cultivator)	4	.82	.71	.90	12.2

TABLE 18. LABOR AND POWER USED PER ACRE FOR MAJOR OPERATIONS ON SOYBEANS.—(Continued.)

Growing soybeans	Number of observations	Hours per acre for outfit			Acres per 10-hour day average
		Average	Low*	High*	
Harvesting soybeans:					
Mowing:					
6′—2 horses	47	1.21	.86	1.50	8.3
Raking:					
10′ dump—2 horses	53	.77	.43	1.00	13.0
Cocking hay by hand	30	4.33	2.40	6.00	2.3
Binding hay—grain binder:					
8′—4 horses	16	1.14	.88	1.43	8.8
Shocking hay	27	1.76	1.07	2.35	5.7
Loading, hauling and unloading hay:					
Out of cock	45	3.25†	2.40†	4.30†	1.33
Out of swath, or windrow—hay-loader	21	2.40†	1.60†	3.40†	1.77
Out of shock	24	2.55†	1.70†	3.70†	2.13
Binding seed beans—grain binder:					
8′—4 horses	35	1.05	.70	1.50	9.5
8′—tractor	13	1.01	.73	1.41	9.9
Shocking seed beans	60	1.49	.80	2.14	6.7
Threshing:					
22″ separator, 10-20 tractor, 8 men, 10 horses	19	.56	.42	.83	18.0
28″ separator, 15-30 tractor, 10 men, 12 horses	25	.45	.33	.60	22.0
Combining: 3-4 men and 2-4 horses					
10′—tractor	9	.74	.50	1.27	14.0
12′—tractor	3	.44	.42	.47	23.0

* One-sixth of the outfits observed were operated at faster speeds than those indicated under "Low" and another sixth slower than "High."

† Per ton. The average yield of cocked hay was 2.35 tons per acre. That of hay loaded out of the swath was 2.3 tons per acre, and the yield of that cut with a binder was 1.84 tons per acre.

with 1.05 hours per acre in shocking oats, these figures indicate that the work goes rather slowly. On an acre basis, threshing seed beans is only about two-thirds as fast an operation as threshing oats.

Order and Number of Operations on Soybeans

While most of the information on the number and order of operations in producing soybeans given in table 19 have been discussed in the preceding pages of this study, another use may be made of these facts. If combined with information obtained from tables 17 and 18, it is possible for farmers to calculate ahead of time approximately what land, labor, machinery and power will be needed in the production of the crop through the growing and harvesting seasons.

Given this physical basis on which to work, the next step is to calculate the best plan of action in view of present and possible future prices and costs. That problem is discussed in the following section.

TABLE 19. NUMBER AND ORDER OF OPERATIONS USED IN PRODUCING SOYBEANS IN IOWA. FOUR REPRESENTATIVE COMBINATIONS OF OPERATIONS.

Growing the crop			
Plow*	Plow*	Plow*	
Disc 2-3 times	Disc 1-3 times	Disc 2-3 times	Disc 3-5 times
Harrow 2-3 times	Harrow 1-3 times	Harrow 1 time	Harrow 1 time
Plant in rows	Drill in 4 rows	Drill solidly	Broadcast
Harrow 1 time	Harrow 1-2 times	Harrow or hoe 1 time	Harrow 1 time
Cultivate 2-3 times	Cultivate 2-3 times		
Harvesting for hay			
Mow	Mow	Mow	Bind
Rake	Rake	Rake 0-1 times	Shock
Cock by hand	Cock with rake	Cure 3-7 days	Cure 10 days to 2 weeks
Cure 2 weeks	Cure 2 weeks	Put up with a hay loader	Put up using slings
Put up by hand	Put up by hand		
Harvesting for seed			
Bind	Bind	Combine	Mow
Shock with fork			Rake
Thresh	Thresh (out of windrow)		Thresh

* If the piece has been in corn the year before, it sometimes is disced before plowing. Where a tractor is used to plow, one section of harrow is often hitched behind the plow. The disc and harrow not infrequently are fastened together behind a tractor; also an 8 or 10-ft. harrow is sometimes fastened behind the drill where a tractor furnishes the power for that operation.

ADJUSTING PLANS IN RESPONSE TO CHANGES IN PRICES AND COSTS OF PRODUCTION

Land, labor, materials, machinery and power outfits used for soybean production may be divided into two important classes. The first includes the resources available on the farm or obtainable from neighbors. The second is made up of those that have to be purchased either for cash or credit. These two groups should be carefully distinguished in calculating the advantage of any plan, for under certain emergency conditions, common when soybeans are being considered, cash and credit may be at a great premium in a farm business. When there is a shortage of cash, plans which require no purchases will hold a decided economic advantage.

A study of the first of these two groups shows that the land, labor, power and machinery available on the farm include two sub-groups: (1) *unused or waste resources* and (2) *resources which may be withdrawn from some other less effective use.*

If the resources required in growing soybeans would otherwise be wasted, then the advantage of a plan for growing the crop should be rather clear-cut. If most or all of the land, labor, power and machinery, however, must be withdrawn from

Fig. 22. One of the most economical and generally satisfactory methods of handling soybeans for hay is to cut with a mower, cure in the swath, rake when tough with dew and load with a hayloader.

other profitable crop or livestock enterprises, then the advantages of soybeans should be scrutinized in considerable detail before giving them a regular place in the cropping system.

The cash outlay items are of two kinds: (1) *cash outlays for operating expenses,* and (2) *long-time investments.*

Of course such cash outlays as seed, commercial inoculation, twine and threshing charge are easily added together and deducted from expected income, but when it comes to long-time investments such as a bean drill, a fair annual charge for the first year's use is hard to determine. What such a charge should be depends upon the usefulness of the machine in making money in future years as well as on its probable years of life and its present cost. If the purchases involved in a plan are chiefly operating expenses, the evaluation of that plan is not difficult. If they are largely long-time investments, many complexities are introduced.

Fortunately, soybeans are especially adapted to emergency conditions and often only a small proportion of the elements of cost involve the problems of a long-time character or require shifting resources from other uses.

DETERMINING THE ADVANTAGE OF EMERGENCY PLANS IN A SPECIFIC CASE

The experience and methods used by one northeastern Iowa dairy farmer, furnish a good example of the evaluation of short-time plans in a case where soybeans were used as an emergency hay crop. Because of a hard winter which partially killed his clover and timothy seeding on a 10-acre field, this farmer faced a shortage of hay. By the middle of May it was evident that the stand was even poorer than he had expected. Something like 14 days of man labor with the necessary horse labor, or its equivalent in tractor time, would be needed to break up the field and put it into soybean hay and harvest it. Yet he decided that this could be done with the greatest chance for gain if he harvested a first cutting of the timothy, which was all that was left, and then plowed up the piece and put it in soybeans.

Of unused resources he would have the necessary land by the first of July and would also have the surplus labor and power usually used in hay harvest after that date. In the fall,

haying could be fitted around silo filling without much difficulty. There was an old wheat drill in the neighborhood. This was rented for 25 cents an acre. No other special equipment was required.

As compared with leaving the field in timothy, the operator figured he would be ahead by the value of the soybean hay he raised on the 10 acres, less $13.50 for seed, $2.50 for drill rental, $5.00 for extra horse feed otherwise salable, $4.00 for twine, and not over $10.00 for the feed value of the timothy stubble plowed up. Some of his equipment would get some extra wear too. Although he had a tractor he decided that it would pay to use all horse power because of the slack in labor around July 1. This would save the cash outlay for gas and oil in the tractor.

Figuring a yield of only a ton to the acre he would save buying 10 tons of hay for the cattle at $6.00 a ton or $60.00 worth, and after subtracting from this the cash outlays and other cost items readily determined, he would still have left a net value of $25.00 as a return for his extra labor and wear and tear on machinery.

The consequence of carrying this plan into effect was that his 10 acres yielded .7 of a ton of timothy to the acre in late June and 1¾ tons per acre of soybean hay in the fall, making the venture considerably more profitable than he had anticipated. On the other hand, it must be remembered that considerable risk was involved in this plan and that part of the profit was a return for carrying this risk.

Nothing in this plan had any permanent effect on this farmer's future plan beyond that year's period except that it kept his livestock feeding plans going forward on a steady basis. In this case, the cash operating expenses were small, no investments of a long-time nature were required, and other costs were avoided by the use of waste resources. The income resulting was the saving of a direct cash expense for hay.

EVALUATION OF SOYBEANS IN A PERMANENT PROGRAM

As already indicated, the competitive strength of soybeans on different soils and for different uses varies widely. On some farms and in some sections of the state, the combination of all these factors is so favorable that the crop has gradually been

adopted as part of the regular rotation. When it appears that this situation exists on a farm certain long-time decisions must be made which are not even considered when beans are used strictly as an emergency crop. Such long-time choices frequently deal with investments in power and equipment. The farmer cannot afford to buy expensive implements with which to handle his soybean crop unless he is quite sure that those implements will be used regularly over a considerable period of years and on a sufficient acreage. Any valuation of the advantage of purchasing an implement under such conditions calls for a much more detailed study of the way the crop normally fits into the farm business program than need ordinarily be made. In addition, it requires a great deal more attention to the future of prices and to the possibility of changes in productive methods than is needed when dealing with an emergency use for the crop.

DO YOU KNOW THAT—

1. Iowa people may have their names put on the mailing list for Iowa Agricultural Experiment Station publications merely by requesting the Bulletin Editor, Agricultural Annex, Ames, Iowa, to do so?

2. Three or four abstract cards announcing new publications are sent to individuals on the mailing list?

3. A list of available bulletins will be sent free to anyone upon request?

4. The mailing list for Station bulletins has increased by nearly 10,000 in the last year?

5. The total number of Station publications mailed out upon request or to mailing lists was nearly 312,000 during the fiscal year 1932-33?

6. More than 52,000 requests for Station bulletins were received during that year?

7. The average requests for each working day totalled 167?

8. During four months—December, 1932, January, February and March, 1933—more than 263 requests were received each working day, and that this increase was attributed to the unusual demand for the circulars, "Agricultural Emergency in Iowa?"

9. There has been a huge demand for the six bulletins dealing with the "Agricultural Recovery in Iowa," a follow-up of the 1933 Emergency series?

10. The Bulletin Office has discontinued its Circular series and that publications formerly appearing in this series are now being published as Extension Circulars?