Extension Bulletin 134
Revised January 1956

SOYBEANS for MINNESOTA

H. L. Jensen
J. W. Lambert
A. C. Caldwell
M. F. Kernkamp

UNIVERSITY OF MINNESOTA
AGRICULTURAL EXTENSION SERVICE
U. S. DEPARTMENT OF AGRICULTURE

CONTENTS

The photographs in figures 9, 10A, 10B, 11, and 13 are used from Illinois Circular 676 through the courtesy of the University of Illinois; figure 12 and 14 are from USDA Farmer's Bulletin 1937.

Soybeans for Minnesota

E. H. Jensen, J. W. Lambert, A. C. Caldwell, and M. F. Kernkamp

SOYBEANS were a minor Minnesota crop only 15 years ago. Today they rank among the state's top cash grain crops. Where production totaled only about 800,000 bushels in 1940, more than 45 million bushels were produced in 1955. The same period saw a shift in emphasis in soybean production. Three-quarters of the 1940 acreage was grown for hay. All but an insignificant part of 1955's two-and-a-quarter million acres was grown for seed and grain.

There were many factors contributing to this rapid expansion of soybean production in Minnesota. Some of them were:

1. Wartime and postwar needs for domestic oils.

2. Greatly expanded uses of soybean oil meal in livestock and poultry feeds.

3. Availability of new and improved varieties.

4. Realization that soybeans can be produced rather easily without costly additions to existing farm equipment.

5. Realization that soybeans can help smooth out the labor peaks during the production season.

6. The fact that soybeans can provide a cash crop which is often more profitable than barley, oats, or flax.

Almost all of the soybean crop, other than seed held back for planting, finds its way into the processing plants.

Oil and meal are the two principal soybean products. Oil makes up a sixth or more of the bean and usually brings two to three times as much per pound as the meal. Soybeans of a high oil percentage are, accordingly, preferred by processors. Oil percentages will vary not only with the variety, but also with the location and year in which the soybeans are grown.

Much of the oil produced goes into human foods such as shortenings, margarines, and salad oils. There are important industrial uses for soybean oil, however, in paints, soaps, linoleum, synthetic resins, and similar products.

A very high proportion of the soybean meal produced is used for animal feeds. It is of special value because of its high percentage of digestible protein. Relatively small amounts of the meal are used in human food or in such industrial products as plastics, glue, and emulsifiers.

1. GROWING, HARVESTING, AND STORAGE

CHOOSING THE VARIETY

Choose the variety best suited for your farm.

Choice of the variety is one factor of soybean production which the farmer can control. In order for a variety to be successful it must be able to mature and produce a good yield of harvestable, high-quality beans under average local growing conditions. Generally, the farther north the location, the earlier the variety must be.

Thus a variety that will mature the last week in September can be used for grain production in the southern tier of Minnesota's counties, but one that will mature by September 1 is needed in the extreme northern counties. If the variety is to be used for

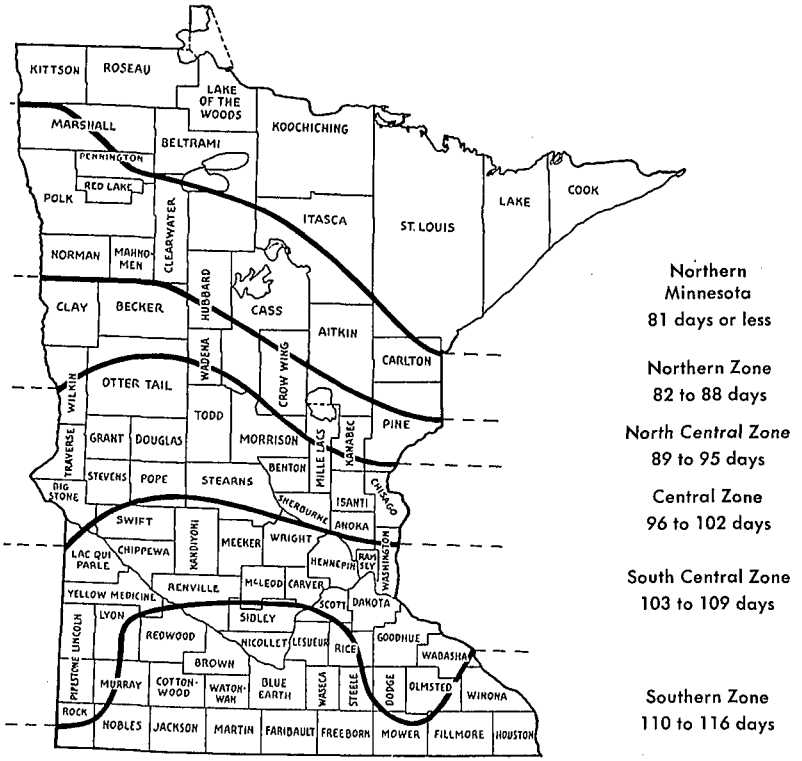

Fig. 1. Maturity zones in Minnesota.

hay only, it can be a week to ten days later in maturity than if it is to be used for grain.

Through the cooperative breeding research of the Minnesota Agricultural Experiment Station, other state experiment stations, and the U.S. Department of Agriculture, new and better soybean varieties are constantly being developed for specific growing areas. Several varieties recently released through this program have proved to be superior to existing adapted varieties in yield, standing ability, resistance to shattering, plant height, and oil content.

The soybean varieties recommended by the Minnesota Agricultural Experiment Station for the several maturity zones of Minnesota are listed in Extension Folder 22, "Varieties of Farm Crops." These recommendations are reviewed each year and frequently revised on the basis of extensive varietal testing throughout the state.

Recommendations made in the 1956 issue of Folder 22 are shown in Table 1.

The map of maturity zones shown (figure 1) is used to indicate the areas of adaptation for the varieties. Obviously, certain varieties have wider adaptation than others, although a variety which is early in the southernmost zone indicated will probably be relatively late in the northernmost zone indicated. The maturity zones listed for each variety are in order of what is considered to be the best adaptation of the variety.

Table 1. Soybean varieties recommended for Minnesota in 1956

Variety	Where adapted
Acme	Northern, Northern Minnesota,
Blackhawk	Southern and South Central
Capital	South Central, Central, Southern, North Central
Chippewa	South Central, Southern, Central
Flambeau	North Central, Central, Northern
Grant	Central, South Central, Southern, North Central
Harosoy	Southern
Norchief	North Central, Central, Northern
Ottawa Mandarin	Central, South Central, Southern, North Central
Renville	South Central, Southern, Central

Detailed results of the varietal trials are published by the Experiment Station each year in Miscellaneous Report 24 entitled, "Varietal Trials of Farm Crops." Folder 22 and Miscellaneous Report 24 are available at offices of county agricultural agents or from the Bulletin Room, Coffey Hall, Institute of Agriculture, St. Paul 1, Minnesota.

Keep up with current varietal recommendations. New and improved varieties frequently become available from breeding research.

SEEDBED PREPARATION

Soybeans respond to good seedbed preparation. The land should be prepared at least as well as for corn. Fall plowing is desirable on heavy soils and to control weeds on all soils. Weed seeds that are near the surface of a fall-plowed field will germinate earlier than those moved to the surface by spring plowing.

Many growers plow in the spring successfully. This practice has the advantage of leaving a cover on the soil surface during the fall and winter, thus

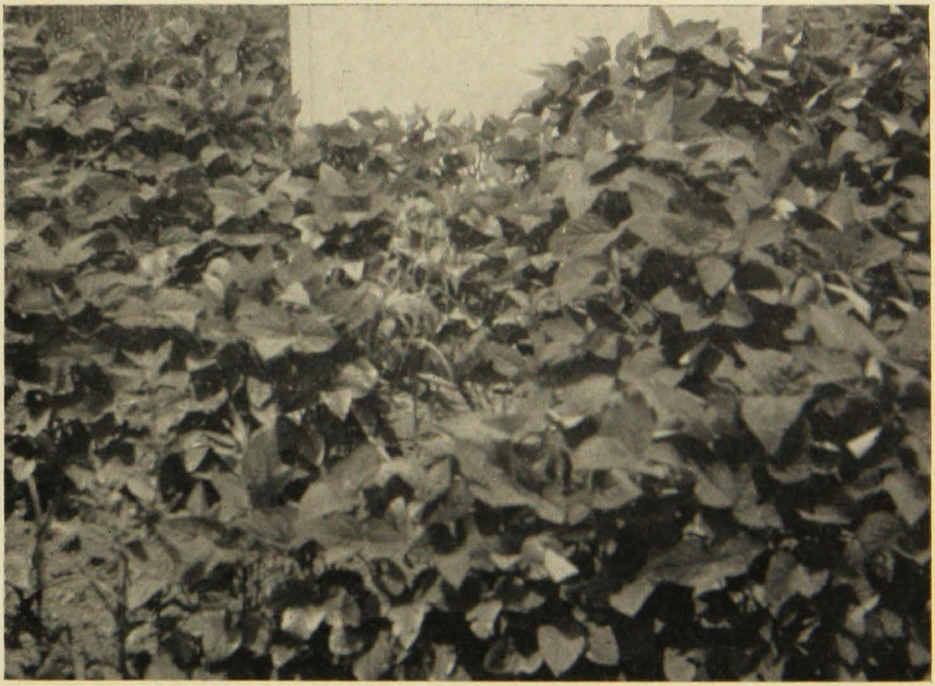

Fig. 2. Soybeans at right indicate the results of applying potassium to a potash-deficient soil.

reducing soil erosion. Also, frequently the corn is not picked in time to allow for fall plowing.

When spring plowing is practiced, it is advisable to plow just as close to planting time as possible. A special effort should be made by extra discing or culti-packing, or both, to prepare a firm seedbed. A good seedbed is firm below and mellow on top. The shorter the time between the last working and planting, the better chance the soybean plants have of controlling weeds through competition for sunlight, moisture, and plant food.

FERTILIZATION

Whether or not soybeans respond to fertilization depends on the nutrient status of the soil. If you are uncertain as to the amount of available plant foods in your soil, have the soil tested. As a general rule if the soil tests less than 150 pounds per acre of potassium (medium level or below) or less than 15 pounds of phosphorus per acre (medium or below), soybeans should be fertilized. Apply the amount of fertilizer that the soil test indicates.

If only relatively small amounts of fertilizer are indicated (up to 125 pounds per acre), application may be made along the row as starter. The soybean is susceptible to fertilizer damage, so care should be taken that none comes in contact with the seed. This is particularly true if the fertilizer contains an appreciable amount of potassium, or nitrogen and potassium. If a soil test shows that the amount of fertilizer needed is more than 125 pounds per acre, it should be broadcast and plowed under or worked into the soil.

Soybeans are a legume crop. Thus, the plant is able to get part of its nitrogen from the air. But in soils where legume crops are not grown very often, use some nitrogen in the fertilizer. Some nitrogen will be helpful also on

Fig. 3. Light-colored plants in center two rows show "iron chlorosis," caused by an iron deficiency in high-lime Minnesota soils.

Fig. 4. Narrower row-spacing, as at right, can increase yields of early or midseason soybean varieties from 3 to 8 bushels an acre.

acid soils where nitrogen fixation may be poor.

Soybeans will respond well to potash when soil supplies are low. Minnesota experiments have shown increases in yield of over 8 bushels of soybeans per acre from the use of potassium on a potash-deficient soil (figure 2). Potassium deficiency symptoms include a yellowing of the leaf edges as early symptoms, with a spreading of the chlorosis and firing of the leaves at more advanced stages.

On high-lime areas of Minnesota, soybeans do not do well because of a deficiency of iron (figure 3). Stunted plants and yellow leaves with green midrib and veins are signs of this condition—called iron chlorosis. It can be cured by a solution of 10 pounds per acre of ferrous sulfate sprayed on the plants. Apply when the weather is cool. Mist the spray on the plants when they are 4 to 6 inches high.

Soybeans do better on soils which are not too acid. Acid soils should be limed to a pH of 6.5.

Fertilizers may affect seed quality as well as yield. Phosphate fertilizers may increase the protein content and phosphorus content of the seed. Potash may reduce the number of shriveled seed and increase the percentage of oil.

INOCULATION WITH NITROGEN BACTERIA

Inoculate seed at planting time for good nodulation.

The soybean plant, being of the legume family, has the ability to support on its roots nodules containing nitrogen-fixing bacteria. This is a convenient relationship for both soybean

plant and the bacteria. The soybean plant manufactures and furnishes all the carbohydrates needed by the bacteria; they in turn provide much of the nitrogen needed by the growing soybean plant.

This nitrogen, derived from the air in a form unavailable to the soybean plants, is fixed or made available by the action of the bacteria. Only one variety of bacteria is capable of cooperating in this manner with the soybean plant. That is, bacteria that live and prosper in close relationship with other legumes, such as alfalfa or red clover, will not produce nodules on soybeans.

It is also known that within the bacterial variety that live on soybeans there are certain strains that fix more nitrogen than others. It is thus obvious that soybean plants heavily nodulated with the proper strains of bacteria have a built-in supply of nitrogen to support their growth.

To make sure that the right strains of bacteria are present in the soil surrounding the roots of the young soybean plants, it is a good and inexpensive practice to inoculate the seed just previous to planting. A number of good commercial soybean inoculants are on the market. Following the directions given by the manufacturer will assure good nodulation of the crop. Seed inoculation is especially important on sandy soils or on any soils where soybeans have not been grown recently.

SEED TREATMENT

Seed treatment is not recommended as a general practice because it usually does not increase yields. However, there are certain advantages from seed treatment. It increases stands, especially if seed is not of the highest quality and if weather at planting time is not favorable to rapid germination of the seed. If seeds are badly weathered, if seed coats are broken, or if seeds are injured internally, seed-treatment chemicals protect them from invasion by soilborne fungi.

There are cases on record where seed treatment has more than doubled stands, but the average increase in stand is about 20 per cent. If seed treatment is used properly, planting rates can be reduced accordingly, about 20 per cent, and the grower will still get the same stand. If growers wish to profit from the advantages of seed treatment, they are certainly encouraged to do so. Spergon, Arasan, or Captan are recommended at the rate of 2 ounces per bushel.

Chemical seed treatment of soybeans is complicated to some extent by the practice of applying nitrogen bacteria to seed to stimulate nodulation. However, tests show that if seed is treated a week to several months before planting, and if the bacterial inoculant is applied immediately before planting, there seems to be little if any interference of the chemical with nodulation.

PLANTING

Time

For most of Minnesota, the best time for planting soybeans is about May 15 to June 1. Often somewhat earlier planting is successful, particularly if rather late-maturing varieties are used. Very early varieties will usually produce mature seed in southern Minnesota when planted as late as July 1. This very late planting is sometimes practiced after a crop of early canning peas is removed.

Mid-May or late May plantings are best. They allow adequate seedbed preparation for weed control and at the same time permit the use of high-yielding, full season varieties.

Row Spacing

The most common spacing of soybean rows on Minnesota farms is 40 inches. This of course is convenient in that it

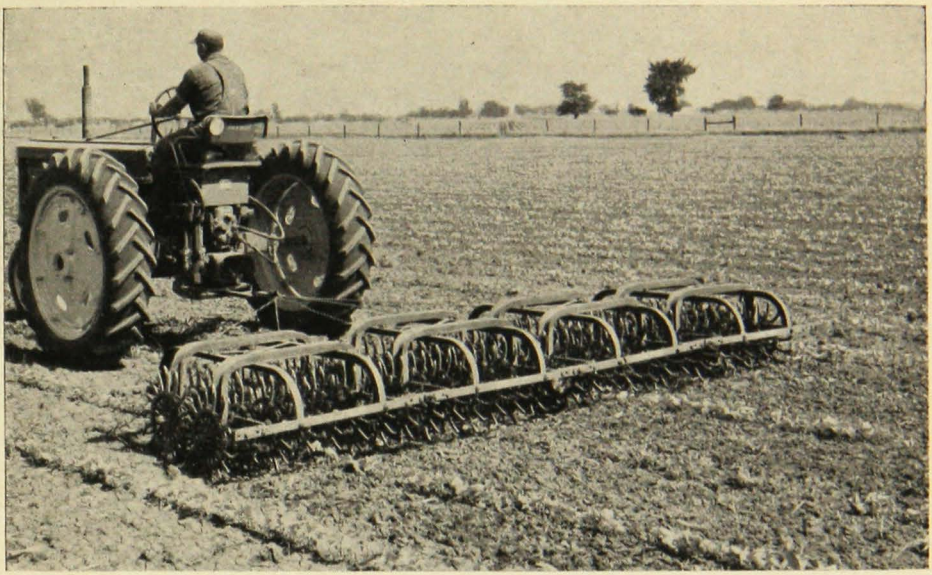

Fig. 5. Using a rotary hoe to kill weeds in soybeans. A spiketooth harrow is equally effective.

is the same as for corn production. However, experiments at several locations in Minnesota have shown that increased yields of 3 to 8 bushels per acre can be expected from narrower row spacings (figure 4). This is particularly true with early or midseason varieties. Later, taller growing varieties give only slight gains in the narrower spacings. The advantage for narrow spacings is apparent in the central or northern counties, or in any other situation where it is desirable to plant the early, short-growing varieties.

There are numerous ways to narrow the spacings. Sugar beet planting equipment serves very well. Placing the planter shoes 36 to 38 inches apart on the regular corn planter is also becoming more and more common. Often the marker is shortened on the two-row corn planter to give alternate 40 and 36-inches spacings. Sowing with a grain drill having a part of its spouts stopped is an additional way of obtaining the narrower spacings. In all cases provision must be made for operation of cultivation equipment.

Soybeans can be sown "solid" with a grain drill. This practice is sometimes useful where fields are relatively free of weeds or when very late planting is necessary. It reduces cost of cultivation and provides a smooth soil surface for efficient operation of harvesting equipment. The greatest disadvantage of "solid sowing" is the lack of opportunity to control weeds by cultivation. Some cultivation with a rotary hoe or harrow can be practiced early in the season but this seldom gives complete control. Some control of weeds in "solid sown" beans can often be effected by sowing winter wheat or winter rye immediately following sowing the beans.

Rates

Experiments have shown that planting rates may vary within rather wide limits without greatly affecting yield. About one plant per inch of row where the rows are spaced at 40 inches apart

appears to be adequate. Approximately 60 pounds of medium size seed (2800 seeds per pound) of good germination (90 per cent or above) will give this plant spacing. Varying that amount 15 pounds, either up or down, will not usually affect yield very much.

Very heavy rates of seeding tend to cause more spindling stems and greater lodging.. Very light rates often result in poor seedling emergence, more weeds within the row, and more low podding and low branching on the stem.

For narrower row spacings, the pounds of seed planted per acre should be increased somewhat. In 24-inch spacings, for instance, the rate should be 90 to 100 pounds of medium-size, good germinating beans per acre. Solid-drilled beans should be sown at about 120 pounds per acre. The actual pounds per acre should always be adjusted to the size and germinating ability of the seed.

Depth

Soybean seed should be planted as shallow as is consistent with placing it in moist soil. This requires careful preparation of the seedbed so that it is fairly firm and well supplied with moisture near the surface. If the soil is very loose, the cultipacker or similar implement may be used to advantage just prior to planting.

Placing the seed at three inches or greater depth in loose soil of heavy texture may result in poor seedling emergence, due to the formation of a thick crust following hard, beating rains. Sandy soils will tolerate slightly deeper planting because surface crusts do not usually form. However, where hard crusts form on the soil surface, they may be broken by use of the rotary hoe, harrow, weeder, or cultipacker.

WEED CONTROL

Several cultural practices control annual weeds in soybeans. Late planting usually results in fewer weeds in the crop, because many weed seeds will have time to germinate and the plants will be killed by seedbed preparation. Cultivation should start early. Use of a spiketooth harrow after the soybeans are planted and before they emerge will help to control weeds. The harrow, weeder, or a rotary hoe may be used when the plants are from 3 to 8 inches high (figure 5). Little damage will be done to the stand if this type of cultivation is used when the plants are slightly wilted, as during the warm part of the day.

Soybeans planted in rows also may be cultivated by an ordinary corn cultivator or a beet cultivator. Two or three cultivations are usually sufficient. Cultivation should be shallow and care taken to avoid ridging, as the ridges make harvesting difficult.

The use of a companion crop of winter rye or winter wheat sown with soybeans, drilled in 6-inch rows sometimes has a place. It can be used where danger of erosion makes sowing the crop in rows to be cultivated undesirable, or where the land for other reasons cannot be cultivated. This method has sometimes been effective against pigweed and lambsquarters. It has not controlled wild mustard, cocklebur, giant ragweed, smartweed or perennial weeds. It has given partial control of annual grasses.

This practice has resulted in better control of weeds, and higher yields of soybeans, than the method of drilling beans with no cultivation or companion crop. Control is not as good as when beans are grown in cultivated rows. One bushel per acre of rye is sown either with soybeans or immediately afterward. The rosette type of growth of the winter grain early in the season offers competition for the weeds. During July the companion crop begins to die and the beans largely recover from the early competition.

Weed control in soybeans by either preemergence or postemergence applications of herbicides has not been dependable. The only postemergence spray rcommended for soybeans is 2,4-D or MCP for cocklebur and wild mustard control. In the seedling stage, these and other susceptible weeds can be killed with 2 ounces of the amine salt. This makes possible the spraying of soybeans. For least injury to the beans, spray when the soybeans are 3 to 5 inches tall.

As an emergency measure where thistles are threatening on land to be planted to soybeans, it would be advisable to spray and delay planting. Treat the thistles after growth has started in the spring, but before seedbed preparation, with 2,4-D ester applied at the rate of 1 pound per acre. Delay working the land for about 1 week. Then proceed with seedbed preparation and planting in the usual manner.

HARVESTING

Soybeans should be combined when the beans contain not more than 14 per cent moisture. However, beans low in moisture content (8-10 per cent) at harvest are very subject to mechanical injury and reduction of germinability. Also, when beans are at very low moisture content, they tend to shatter. Other losses in the field may occur when the surface of the land is rough or when the combine travels too rapidly. (Figure 6.) Losses of 40 beans per square yard represents a loss of about one bushel per acre.

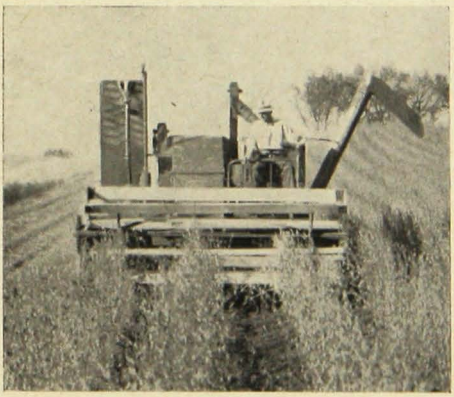

Fig. 6. When combining soybeans, proper mechanical adjustment and a proper rate of speed help cut field losses.

Field losses thus can be reduced by planting varieties that are not prone to shatter, maintaining a level field by careful cultivation, harvesting before the beans are overripe, and careful operation and adjustment of the combine.

Not only is the proper adjustment of the combine important to prevent field losses but also to reduce splitting and breakage of the beans. A reduction of cylinder speed and adjustment of the concaves help to prevent the cracking of soybeans. If the manufacturer's recommendations for adjustment and operation of the combine are followed, usually the splitting of the beans is slight. One exception may be when the beans are very dry. If this occurs, it would be advisable to combine only in the morning or evening when the humidity is high.

Recommended varieties usually mature, and green leaves and stems are not a problem in harvesting. However, under certain conditions the presence of green crop material and weeds complicates harvesting. To combat this problem, chemical defoliant sprays can be used. DNBP, applied at the rate of 1.25 to 1.87 pounds, or 2 to 4 pounds of PCP applied in 5 to 10 gallons of diesel fuel per acre, is suggested. Endothal formulation may also be used. These treatments should be applied when the beans are nearly mature otherwise some reduction in yield and quality may be expected.

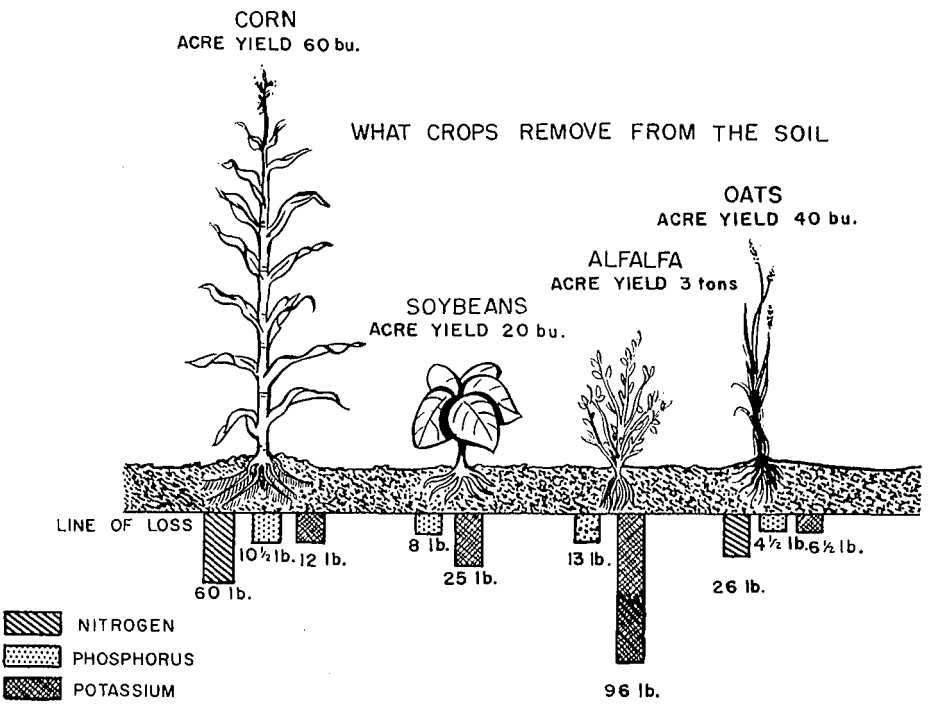

Fig. 7. Plant nutrients removed from the soil by soybeans. Amounts removed by average yields of corn, alfalfa, and oats are shown for comparison.

STORAGE

Soybeans may be stored safely for short periods of time in the fall and winter with moisture content as high as 14 per cent. For longer storage and carryover into the warm spring and summer months, the moisture content should not exceed 12 per cent. Beans low in foreign material and in percentage of splits stay in good condition longer than dirty or carelessly handled beans. As in the case of any other grain, tight weather-proof bins are essential to proper storage.

II. SOYBEANS AND THE SOIL

ADAPTATION

Soybeans are adapted to nearly all soils, but produce best on the more fertile soils. They are preferred to corn as a crop on wet lands, chiefly because they can be planted later. Soybeans are relatively drouth resistant (in this respect better than corn), and do well on sandy soils. They can be grown on peats and mucks.

EFFECT ON SOIL

Chemical

Soybeans, like any other crop, will remove nutrients from the soil. How much depends upon the yield, use, and method of handling. Figure 7 indicates the amounts of nitrogen, phosphorus, and potassium which an average yield of soybeans will remove from the soil—compared to that removed by average yields of corn, alfalfa, and oats.

When the grain is sold off the farm, large amounts of the major fertilizing elements are removed without being returned in any manner. However, even though a legume, the soybean does not contribute particularly to the nitrogen content of the soil. The grain used for processing and the seed held for planting contain large amounts of nitrogen; the straw contains little. With a ton-and-a-quarter of straw containing only 15 pounds of nitrogen, little can be returned to the soil when the straw remains in the field. Furthermore, only about 10 per cent of the plant is roots, so there is little in the way of a nitrogen contribution there.

Physical

Soybeans have a mellowing effect on the soil following their use. This physical condition seems to be especially suitable as a seedbed for small seeded legumes and flax. Because of the favorable structure it is not necessary to

Fig. 8. How damping-off and root rot affect soybean seedlings. A healthy seedling is shown (second from left) for comparison with diseased seedlings.

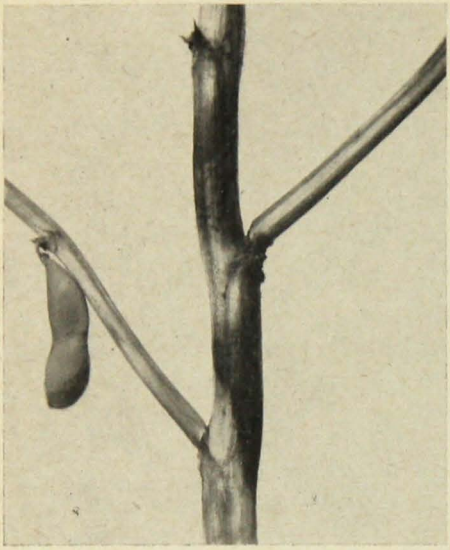

Fig. 9. Stem canker of soybeans (note black areas on main stem).

plow for most crops following soybeans, except where the straw is very heavy or weed situation is bad.

CROPPING SEQUENCES

Soybeans can be used as the row crop in any rotation. The location of soybeans in the rotation should be such that they do not follow soybeans or other legumes, largely because of disease difficulties. Frequently the crop follows small grains or corn, but corn stalks should be plowed under. Soybeans can be beneficial to the crops which follow; it has been shown that corn and oats are better following soybeans than when following corn. Because of good structure and weed control provided by soybeans, flax appears to be a suitable crop to immediately succeed soybeans in the rotation.

III. SPECIAL USES

EMERGENCY HAY CROP

Soybeans are a desirable, emergency, high-protein hay crop when alfalfa and clovers fail. You can expect 2-3 tons per acre. This crop makes the best quality hay if it is cut when the lower leaves start to drop and when the pods are about one-half filled. On the basis of dry matter consumed, soybean hay has about the same feeding value as alfalfa hay of a like grade, but there is more waste in feeding soybean hay because of the coarse stems left by the livestock. As a result, soybean hay is commonly given a value which is equal to 85 per cent of the price of alfalfa hay.

Tests in Minnesota where weeds were no problem have indicated drilling will give the highest forage yields. The soybeans should be sown at about the rate of 2 bushels per acre. One should consider planting the later maturing varieties as they are likely to give higher forage yields than the earlier one.

Curing hay has been a difficult problem. Under most Minnesota conditions nearly complete curing in the swath, followed by raking or windrowing when the hay is damp from the morning dew, is most practical. The drying is completed in the windrow.

Other ways to handle this crop would be to let it dry in the swath for a few days and then rake, cock, and cure until suitable for storing. Quality hay may also be made if soybeans are cut with

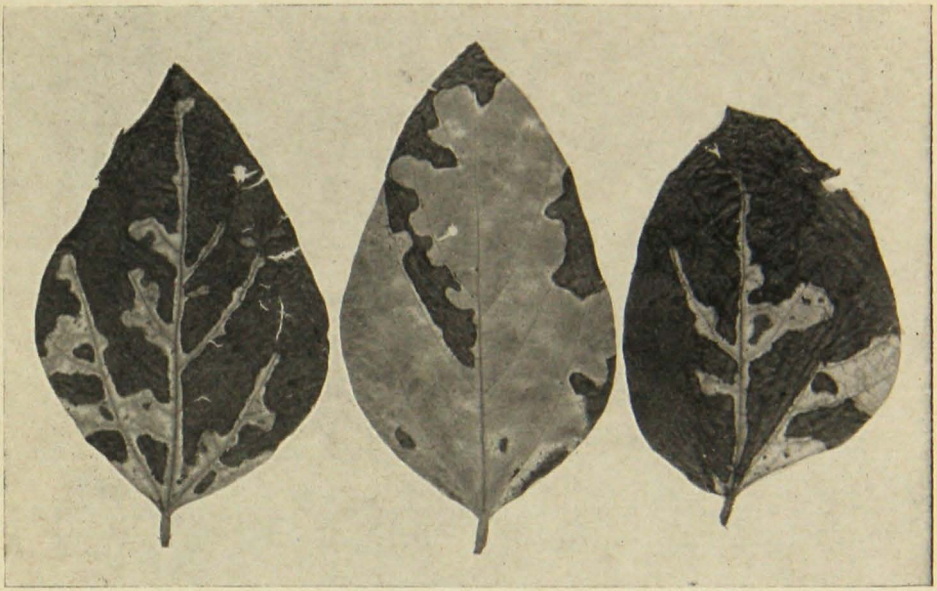

Fig. 10A. Leaf symptoms of brown stem rot.

a binder, bound loosely, and allowed to dry in long shocks.

SILAGE

A combination of sudan grass and soybeans has given the highest yields of the supplemental forage crops. When this combination is used, drill 10 to 15 pounds of sudan grass with one bushel of soybeans. This should be ensiled when the sudan grass starts to head or before frost. This crop should be cut and handled similar to corn for silage.

Occasionally, an early frost will prematurely kill the soybeans. If the leaves have not started to drop and the pods are not filled one could make silage of this crop. This should be ensiled immediately after frost before the leaves drop. Always use a preservative when ensiling soybeans alone. Ground grain, molasses, or sodium metabisulfite are satisfactory preservatives.

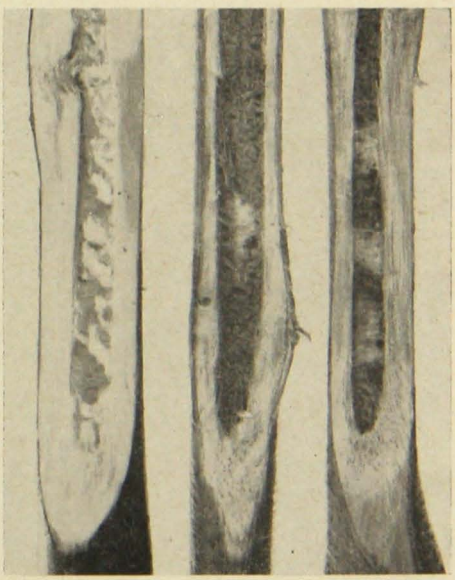

Fig. 10B. Cutaway section of healthy soybean plant (left) compared with two plants attacked by brown stem rot.

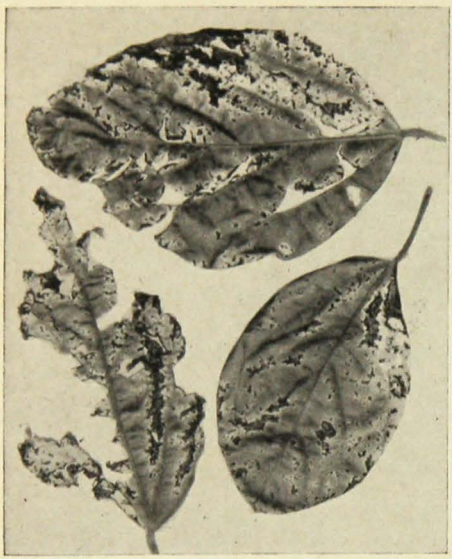

Fig. 11. Soybean leaves showing effects of bacterial blight.

GRAIN FOR FEED

Relatively few soybeans are threshed and fed whole, or ground as a protein concentrate. The oil in soybeans, which runs from 17 to 20 per cent by weight, is generally worth more for food and industrial products than for livestock feed.

Feeding tests with dairy cattle have shown that ground soybeans are about equal to cotton seed and linseed meals. When fed to fattening hogs in amounts sufficient to supply the needed protein, whole or ground soybeans will produce undesirable soft and flabby carcasses.

However, after the oil has been removed the resulting product, soybean meal, has about the same percentage of digestible protein as cottonseed meal, and a little higher percentage than linseed meal. Soybean meal makes a satisfactory high-protein feed for all classes of livestock.

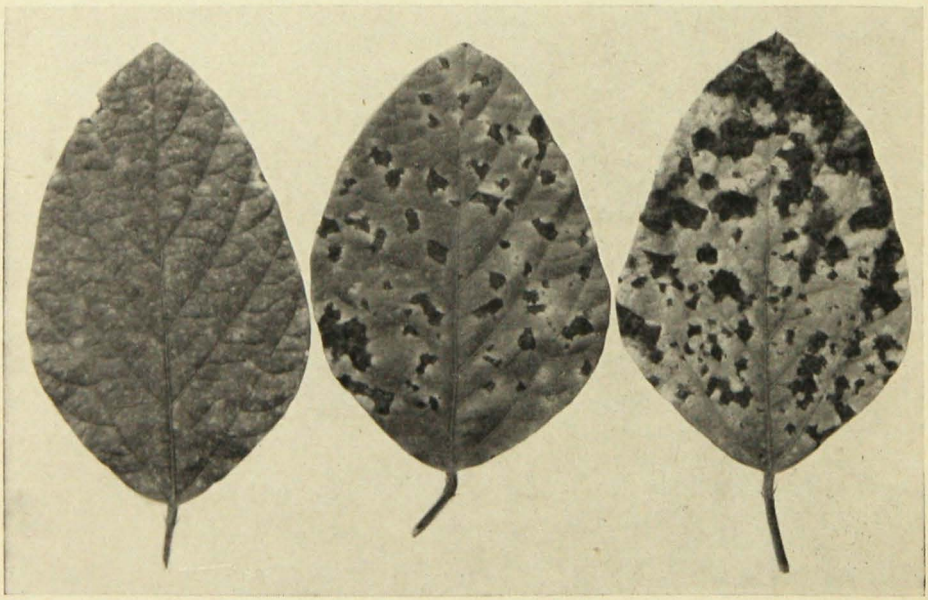

Fig. 12. Downy mildew. Effects of the fungus are just beginning to show on soybean leaf at far left.

IV. DISEASES OF SOYBEANS

Several diseases of soybeans are very common in Minnesota. Fortunately, none of them is extremely serious or epidemic at the present time. Potentially they are a real cause for concern, however, for as more soybeans are grown the diseases probably will become more severe, causing greater losses.

For easy reference, details on the most common diseases are presented in tabular form on the pages following. Table 2 gives a brief description of each disease, its cause and development, the best treatment which can now be recommended, and other pertinent remarks. With the exception of brown spot, for which no photograph is available, the diseases are illustrated in Figures 8-14.

Table 2. Diseases of Soybeans

Description	Causes and development	Treatment	Remarks
DAMPiNG-OFF AND ROOT ROT—Decay of seed and death of seedlings before emergence. Damping-off after emergence; brown roots and stem bases with lesions at ground level. Rotting and destruction of roots. (See figure 8.)	*Fungi.* Soil-borne. Develops at all stages of growth. Usually occurs in proportions of rows or patches 3 to 30 feet in diameter in fields. In severe epidemics entire fields must sometimes be reseeded.	*Crop rotation.* Use the best quality seed. Seed treatment with 2 ounces per bushel of Arasan, Spergon, or Captan.	If seed treatment is used with bacterial inoculant, chemical should be applied weeks to several months before planting. Inoculant should be applied immediately prior to planting.
STEM CANKER—Wilting of entire plant before leaves begin to mature. Brown-to-black canker at attachment of first leaves above ground level (figure 9).	*Fungus.* It lives in soil, seed, and plant debris. Symptoms do not appear until mid-August, when the leaves of plants start to turn color.	*None.* "Blackhawk" and "Hawkeye" are most susceptible varieties grown in Minnesota.	The disease appears late, varieties are early, season is short, so little damage is sustained in Minnesota. Very destructive in southern part of corn belt.
BROWN STEM ROT—Sudden browning of leaves between lateral veins (figure 10A). Brown discoloration inside lower portion of stems; later all of the inside of stem becomes conspicuously brown (figure 10B).	*Fungus.* It is soil-borne. Enters plants through roots. Symptoms often appear in warm period following cool weather in late August.	*Do not plant soybeans in one field more often than once in four years.* Rotate with corn and cereal crops.	Disease new in Minnesota. Develops late in season. Little damage in Minnesota, but destructive in central corn belt states.
BACTERIAL BLIGHT—Angular, yellow water-soaked leaf spots, becoming brown in center (figure 11). Leaves become yellow; shred and fall prematurely. Brown spots on stems in severe infections.	*Bacteria.* Favored by temperatures near 75° F. and wet, humid weather. Bacteria are seed-borne and live on debris in fields. Plants infected at all stages of growth.	*Crop rotation.* Avoid cultivating when leaves are wet, because bacteria are spread by machinery.	Bacterial blight is one of the most common diseases in Minnesota. Losses estimated up to 5 bushels per acre in severe epidemics.

Diseases of Soybeans (continued)

Description	Causes and development	Treatment	Remarks
BROWN SPOT—Reddish-brown spots mostly on lower leaves. Infected leaves turn yellow and fall. (Not illustrated.)	*Fungus.* Develops during wet humid weather in June. Fungus overwinters in infected leaves in fields. Plants seldom infected after midseason.	*Crop rotation.* Avoid cultivating when leaves are wet, because fungus is spread by machinery. Plow under infected plant parts.	Easily confused with bacterial blight. Microscopic examination necessary for definite identification.
DOWNY MILDEW—Green spots on upper surface of leaf; grey tufts of moldy growth on lower surface (figure 12). Leaves turn yellow and fall.	*Fungus.* Develops during cool, wet weather in early part of the season. Fungus is seed-borne, and can overwinter on dead leaves in the field.	*Crop rotation.* Plow under infected plant debris.	Severe infection results in defoliation and reduction in yield. Seeds of some varieties become infected and seed coats are injured.
MOSAIC—Mottled green and yellow, crinkled, and distorted leaves (figure 13). Yellow, light-green, very dark green, and bronze discolorations of leaves. Stunting and yellowing of entire plant.	*Viruses.* Caused by several viruses, some seed-borne, some transmitted by insects, some spread mechanically.	*None practical.*	Infected plants scattered throughout fields. Symptoms of some viruses are identical to 2,4-D injury. Severely infected plants produce no seed.
PURPLE SEED STAIN—Purple discoloration on portions of seed. Wrinkles and cracks in seed coat in discolored area. (See figure 14.)	*Fungus.* Develops on seed in pods late in the fall after plants are ripe. Develops especially when crop stands during periods of cold wet weather.	*Crop rotation.* Avoid planting infected seed. Seed treatment with 2 ounces of Arasan, Spergon or Captan per bushel.	Seed quality reduced. Seed down graded in the trade. Seedling blight sometimes results from infected seed.

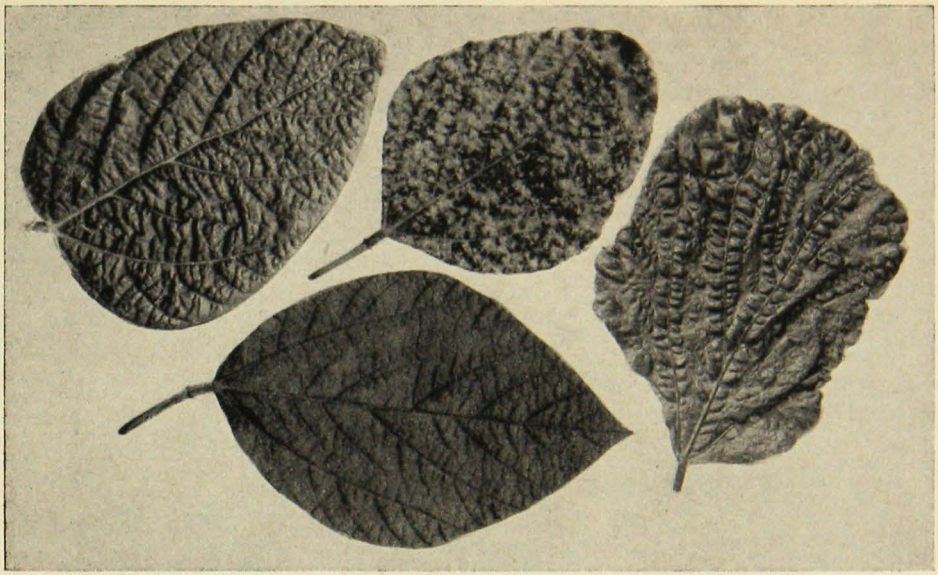

Fig. 13. Mosaic on soybeans can be identified by the distinctive crinkling and distortion of the leaves. Compare appearance of three leaves at top with healthy leaf at bottom.

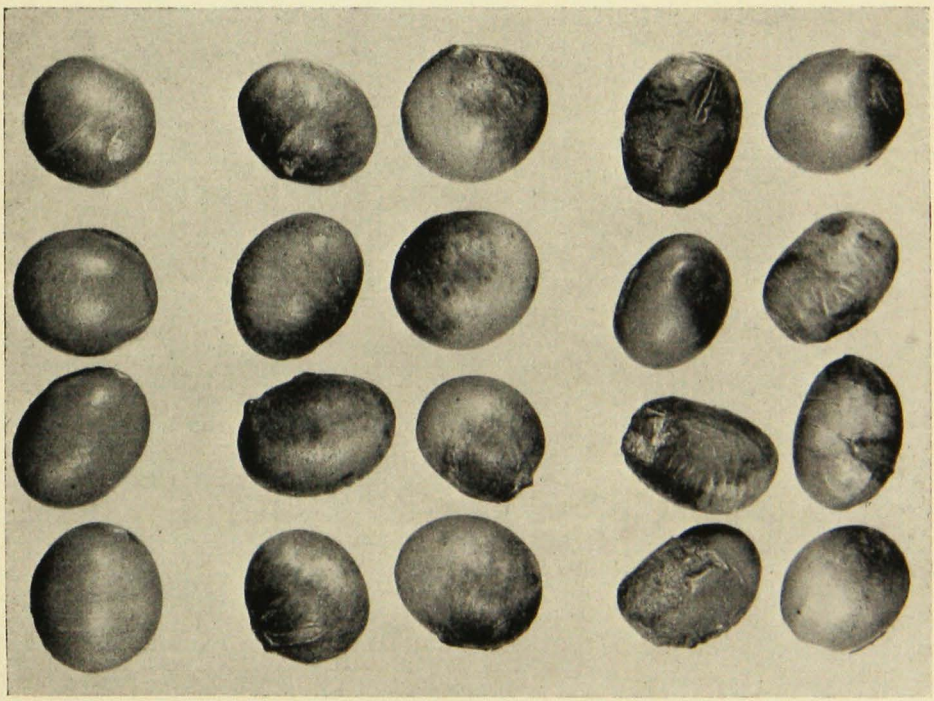

Fig. 14. Purple seed stain. A single row of healthy seeds (left) is shown for comparison. The fungus also wrinkles and cracks the seed coat.

SUMMARY

Use adapted varieties—Follow University recommendations based on many trials.

Use good seed—Be sure with certified seed. Certified seed guarantees known variety of high quality.

Use proper crop sequence—To reduce losses from root rot and other diseases, plant soybeans after small grains or corn. Avoid planting soybeans after soybeans, after other legumes, or after flax.

Plan for high fertility—Follow a good crop rotation. Use fertilizer and lime as needed. Prevent erosion. Provide proper drainage.

Inoculate with nitrogen bacteria—Inoculate the seed just before planting.

Plant in narrow rows—Use narrower row spacing for high yields.

Kill weeds early—Use rotary hoe when weeds are small. Spray for cockleburs when beans are 3 to 5 inches tall.

Harvest carefully—Combine at 10 to 14 per cent moisture. Reduce cutter-bar losses. Check cylinder speed and other fittings frequently to prevent seed injury and losses.

Store properly—Test beans for moisture. Moisture content should not be over 12 per cent for long storage. Remove foreign matter; clean beans keep best.

UNIVERSITY OF MINNESOTA, INSTITUTE OF AGRICULTURE, ST. PAUL 1, MINNESOTA

Cooperative Extension Work in Agriculture and Home Economics, University of Minnesota, Agricultural Extension Service and United States Department of Agriculture Cooperating, Skuli Rutford, Director. Published in furtherance of Agricultural Extension Acts of May 8 and June 30, 1914 25M—12-55