Soybean Production in Michigan
Michigan State University Extension Service
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CONTENTS

MICHIGAN FARMERS HAVE PRODUCED soybeans on slightly less than 500,000 acres per year for the past 3 years (1966-68). The 10-12 million bushel crop was valued at 25 to 30 million dollars annually. Among crops grown for all purposes it ranks fifth, as a cash crop third. The acreage has doubled in the past 10 years. Of the ½ million acres, about one-third are in Monroe and Lenawee counties in southeastern Michigan.

Uses of Soybeans

Almost all of the soybean crop is produced for beans with small acreages for forage and green manure. Most of the beans are processed into oil for use in shortenings, margarine and salad oils, and oil meal which is high in protein and widely used as a supplement in livestock feeds. Soybean products are used also in a great variety of foods, plastics, paper, fabrics, adhesives, soaps, paints and varnishes.

The U. S. soybean industry is well organized and active in marketing soybeans and the products derived from them, both at home and abroad. As a result, soybeans are now the leading export crop of the U. S. Soybeans may be used to alleviate the world shortage of protein in human nutrition.

Adaptation

Soybeans are adapted to most areas where corn will mature for safe ear corn storage. The crop will grow on a wide range of soils but does best on fertile, well drained soil. It does not produce good yields on infertile, droughty soils but is more tolerant of droughty and imperfectly drained soils than field beans. Soybeans can be produced successfully on well-drained organic soils where late spring frosts and early fall killing frosts are not a serious problem.

The use of chemicals for pest control prior to planting may result in residue problems. A field check should be made to determine residue in a field before making plans to plant the field to soybeans.

Soybeans are responsive to day length and require a longer growing season in northern growing areas than in southern because of the long summer days. Because of this and a shorter growing season, earlier maturing varieties must be used in the northern part of the state. Their yield per acre is lower than varieties which will mature farther south. In general, soybeans are not well adapted to areas north of Newaygo, Isabella, Midland and Arenac counties. Because of the "lake" effect on growing season there are a few areas in the vicinity of Grand Traverse Bay where soybeans might be produced successfully.

Soybeans can take the place of any row crop in the rotation. They will respond to the plowing down of a forage legume crop but not so well as corn, so they usually follow corn in a rotation. Soybeans may do well following soybeans on a fertile soil. However, continuous production increases the possibility of disease and insect buildup. Several important diseases are soil borne.

Yield Goals

The yield of soybeans is dependent upon many factors, the kind of soil being one of the more significant. Table 1 gives the long-time average soybean yields that should normally be expected where good soil and crop management practices are followed on several kinds of adequately drained soils.

Some producers may set yield goals above those shown and this is desirable. The figures in Table 1 might be adjusted slightly upward on the most fertile soils, especially in the southeastern section of Michigan but they are realistic for most of the state. For more information on soil management groups refer to MSU Extension Bulletin 550, Fertilizer Recommendation for Vegetable and Field Crops in Michigan.

VARIETY SELECTION

Variety selection is one of the most important things which a producer can control. In making a selection you must consider (1) yield, (2) maturity, (3) lodging resistance and plant height, (4) oil and protein contents, and (5) disease resistance. Select those varieties which have the best combination of desirable traits for your situation. Seldom does any one variety excel in all respects.

Data covering these and other factors are furnished in Mimeograph File 22.17, Soybean Variety Comparisons in Michigan, which is revised each year. Table 2 lists the significant characteristics of some of the most highly recommended varieties of soybeans, when grown on productive mineral soils.

Table 1. Long-time Average Yield Goals for Soil Management Groups.

Soil Management Group	Bushels per acre
0c	25
1a	28
1b	32
1c	35
2a	32
2b	35
2c	40
3a	30
3b	33
3c	35

Table 2. Comparison of Recommended Varieties of Soybeans for Mineral Soils

Variety	Average days to mature*	Plant height inches	Lodging resistance	Seed size	Area where adapted and remarks
Portage	105	28	Very Good	Small	A very early variety for northern areas or for muck soils in central Lower Michigan.
Chippewa 64	117	32	Very Good	Small	An early variety for north central Lower Michigan and to precede wheat in southern Lower Michigan. Resistant to Phytophthora rootrot.
Hark	123	35	Very Good	Medium	Widely adapted in southern and central Lower Michigan. An early variety in southern tier of counties.
Harosoy 63	128	40	Fair	Large	A mid-season variety for the southern two tiers of counties. Resistant to Phytophthora rootrot. Lodging a problem on fertile soils.
Corsoy	129	38	Fair	Medium	Same adaptation as Harosoy 63.
Amsoy	132	40	Good	Medium	Adapted to southern tier of counties.

Days to mature: The days to mature is an average. For any one season this may vary 5 days earlier or later.

Maturity

For the highest yield per acre of the highest quality product, choose varieties which normally mature by the time of the first killing frost for your area. A mid- to full-season variety usually gives the highest yield per acre.

The more immature the crop by killing frost time, the lower the quantity and quality of the harvested crop. In Figure 1, the monetary return from the high quality beans on the left would far exceed that from the other two lots, even if the yield per acre were slightly lower.

If the soybean acreage is large, two or more varieties differing 5-7 days in maturity should be considered. This provides for a lengthening of the optimum harvest period for the entire crop and helps reduce harvest losses from shattering of overripe beans. If you plan to plant wheat after soybean harvest, an earlier variety would be required for the wheat acreage.

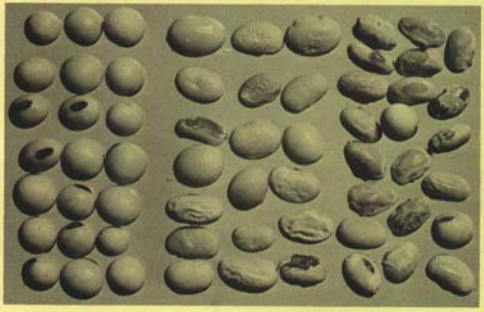

Fig. 1 — Effect of maturity on the quality of soybeans: Left — Excellent quality, mature at time of killing frost. Center — Poor quality, partially mature at time of killing frost; Right — Very poor quality, immature at time of killing frost.

Fig. 2 — Note the distance between ground level and the bottom pods of the tall and short varieties.

The varieties recommended for Michigan vary in maturity from about 105 to 132 days from planting to harvesttime. For the main soybean areas of the state both early and full season varieties are recommended See Table 2.

Lodging Resistance and Plant Height

On highly fertile soils, some varieties stand quite well for combining while others lodge seriously. Those which lodge on the fine textured soils may stand well enough for combining on sandier, less fertile soils. Shorter varieties may make enough growth on the fertile soils to allow successful combining, but on the less fertile soils, plant growth is so short that combining is difficult.

Usually the shorter varieties stand better than the tall ones. Frequently the taller varieties have bottom pods higher from the ground than the shorter varieties as shown in Figure 2.

Disease Resistance

A practical and economical way of controlling soybean diseases is the use of resistant varieties. Soybean breeding programs emphasize resistance to those diseases which are the most serious in a state or region. Of the varieties currently recommend for Michigan only a few have resistance to any one disease. Chippewa 64 and Harosoy 63 have resistance to Phytophthora rootrot, a special rootrot disease which has caused some difficulties in Michigan on heavy

clay soils. Harosoy 63 is also one of the least susceptible varieties to stem canker. There are no varieties with resistance to the common rootrot complex (Rhizoctonia, Furarium, and Pythium species), bud blight, brown stem rot, and bacterial blight. See discussion in disease section of bulletin.

SOIL MANAGEMENT

Preparation

To be effective, soil preparation methods should be related to weed and insect control, the effective use of fertilizer and lime, and to rapid seed germination and root growth. In some systems of farming, soil preparation may be closely related to methods of disposing of trash, manure or residues from a previous crop.

Soybeans grow well on both spring- and fall-plowed soil. On one set of experimental plots at MSU where the soil was in good physical condition, soybeans grew well on both shallow and deeply plowed plots. On soils that were compacted during the harvest of the previous crop, plowing to a depth of 9 to 12 inches was beneficial.

Soybeans grow best on a loose, porous soil. Therefore, growers should be careful about working the soil more than is absolutely necessary. Excessive tillage results in (1) crust formations, (2) slow water drainage and (3) possible oxygen deficiency.

A good job of plowing with a well-adjusted moldboard plow is one method of easily preparing the soil for rapid seed germination, a good stand and high yields.

Liming and Fertilization

Soybeans grow best on soils that are not greatly acid or alkaline.

One of the reasons for soybean production being concentrated in certain counties in Michigan is undoubtedly related to the naturally desirable pH level found in the soils of Monroe, Lenawee, Shiawassee, Gratiot and Saginaw counties.

On acid mineral soils, the application of lime several months before planting is important. If necessary, apply lime in amounts to change the soil pH to approximately 6.5. At this pH level, most of the essential plant nutrients are readily available to the soybean crop. If the pH is significantly below 6.5, manganese and aluminum may be toxic. If the pH is greatly above 6.5, manganese deficiencies may be induced on sandy soils, low in organic matter.

Soybeans have not responded greatly to the use of commercial fertilizer, although they do require very high soil fertility. The high yields in the top counties in Michigan reflect not only the naturally desirable pH conditions, but also the fact that the soils are naturally fertile and that the soils in these counties have historically produced record crops under high rates of fertilizer.

Soil testing is the basis for determining how much of what kind of fertilizer to use for soybeans. Rates of nitrogen up to 40 pounds per acre are recommended where soybeans follow corn or a small grain and where no manure is used. This recommendation is unique to Michigan. States to the south do not show any yield response from nitrogen fertilizers.

Rates of phosphate fertilizers up to 50 pounds of P_2O_5 per acre are recommended, depending upon the soil test results and the yield goal. Soybeans, according to data in the Michigan fertilizer recommendations bulletin, should never be planted without the benefit of at least 25 pounds of P_2O_5 per acre. Regardless of how low the soil test results are, the use of 50 pounds of P_2O_5 is usually sufficient to produce a 50-bushel crop.

Where soil tests for potassium are above 180 pounds per acre, no potash is required to produce 50 bushels per acre. Where yield goals are above 50 bushels, some potash should be used.

Manganese

Soybeans frequently need manganese when grown on organic soils and dark-colored sandy soils with pH higher than 5.8, and in depressional soils or on lakebed soils having a gray subsoil with pH above 6.5. To prevent manganese deficiencies, use 8 to 10 pounds of manganese per acre on mineral soils. For organic soils, use 10 pounds per acre between pH 5.8 and 6.4, 20 pounds between 6.5 and 7.2 and 40 pounds per acre when the soil pH is above 7.3. For more details refer to Extension Bulletin E-550, Fertilizer Recommendations for Michigan Vegetables and Field Crops.

Fertilizer Placement

Soybeans are very sensitive to fertilizer placed in contact with the seed. The ideal placement, which is difficult to achieve with some kinds of planters used today, is 1 inch to the side and 2 inches below the seed level.

SEED SELECTION

Use High Quality Seed

The soybean grower has almost complete control over seed selection. Other investments in the crop are so high that he must use this control to the best advantage and plant the highest quality seed possible.

Selecting seed by sight is not good enough. You

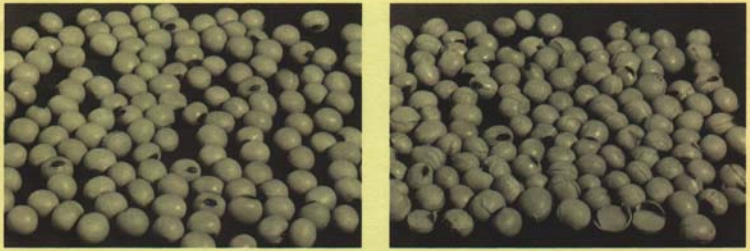

Fig. 3 — Seed quality: Left, sound seed; Right, seed with cracked seed coats.

cannot accurately tell whether good looking seeds will produce healthy plants. Guessing can be costly. High quality seed should have these qualities:

(1) high varietal purity
(2) high crop purity (pure seed)
(3) relatively free from cracked and split seeds, stems and dirt
(4) free from weeds and other crops such as corn
(5) uniform seed size and
(6) high laboratory germination (85% or above).

Certified seed is the main source which meets all of the above requirements. Obviously, bin run seed cannot meet them. It is neither selected nor prepared. If used, it should be well screened and a germination test should be run to determine its viability.

Regardless of the seed used, whether home grown, certified or other, special attention should be given to its mechanical condition. Select sound seed. Seed having a high percentage of cracked seedcoats will seldom produce a good stand of normal, healthy plants. Many plants from such seed are stunted, develop slowly, or may fail completely. Mechanical injury to the seed is most likely to occur in dry harvest years when the seed is low in moisture during combining. Serious mechanical injury can usually be detected visually but must be verified by laboratory germination tests. See Figure 3. There is no seed treatment which will improve the germination of a seedlot damaged mechanically.

Make sure the seed you purchase carries an analysis tag. The tag is required by law and carries information concerning seed quality factors.

Seed Treatment

Seed treatment with a fungicide and/or insecticide may be effective in preventing seed decay, damping-off of seedlings and maggot injury. These occur most frequently when wet and cold weather prevail at planting time and the conditions hinder quick sprouting of seed and seedling emergence. In recent years, using high quality seed, tests have shown little advantage for seed treatment. In certain cases the germination of an otherwise good seedlot might be increased by a seed fungicide treatment providing the injury is not mechanical.

If treatment with a fungicide seems called for, the most common materials in use are Thiram and Captan. Each of these materials is sold under several trade names. In treating seed, follow the directions of the manufacturer for dosage and method of application. If both seed treatment and inoculation are required, the seed should be treated several weeks in advance of planting and the inoculant applied just before planting, preferably in the planter box.

Seed Inoculation

Soybeans use a lot of nitrogen in making a 50-bushel per acre crop of beans. The most economical way to get most of this nitrogen is to have the plants manufacture their own supply. The safest way to be sure of good nodulation on the roots and manufacture of nitrogen is to inoculate the soybean seed with the proper bacterial culture each year. It is good insurance at low cost although research has shown that annual inoculation is not always necessary. Follow the directions of the manufacturer in applying inoculant to the seed.

PLANTING

Time — In the southern Lower Peninsula May 15-20 is a good time to start planting soybeans on well-drained soil. Usually soybeans are planted after corn

because corn suffers more from later planting. Normally you could use a mid-season variety until about June 1. After that date a change to an earlier variety is advisable. A delay in planting of 15 days frequently results in a delay in maturing of about 5 days. In trials, yields have been considerably lower when the planting date was June 15 or later.

Depth — Under many conditions, planting seed at a 1- to 2-inch depth is satisfactory. For all conditions, plant deep enough to place the seed in moist soil but not deeper than 3 inches on sandy soils, and less on heavier soils.

Row Width — There is extensive data from states in the northern soybean area on row width. Representative of the results obtained is that from East Lansing, Michigan:

Row width (inches)	Yield per acre (bushels) 3-year average
7 (drilled)	37.7
14	37.0
28	31.1
35-42	28.7

Results from other northern states and preliminary results from Michigan tests indicate that the yield from 18- to 21-inch rows would range about midway between that of 14- and 28-inch rows. *The data above were obtained where weeds were controlled by chemical and/or mechanical methods.*

Regional tests indicate that yield increases in favor of narrow rows are high (1) in northern when compared to southern production areas, (2) for early as compared to later maturing varieties. Varieties with narrow plant type and more upright leaves seem better-adapted to narrow row culture.

The yield data would indicate that more Michigan farmers should plant soybeans solid (drilled). However, these data were obtained under weed-free conditions. Observation of Michigan soybean fields shows that in most years weeds cannot be controlled very well in a solid planting. Herbicides plus one early rotary-hoeing would not do the job consistently. In the final analysis, for high yield of soybeans and fewest weeds, use the narrowest row possible which will allow the use of a cultivator if required.

Table 3. Soybean Plant Populations.

Row width (inches)	Desired stand plants per acre	Seeds per acre to get desired stand
7 (drilled)	250,000	300,000
21	200,000	240,000
28	148,000	180,000
36	116,000	145,000

Planting Rate — Row width and plant population go together in soybean production. An increase in plant population with no change in row width is insufficient. In general, as the row width decreases the plant population increases with the distance between plants in the row remaining constant. Extensive research has shown that the optimum plant stand in rowed soybeans is *8 to 10 plants per foot* of row, down to an 18-inch row width. In drilled (solid planting) soybeans the plants should be about 4 inches apart. In MSU trials, thicker stands than the optimum did not increase yield and lodging was greater. Slightly thinner stands than the optimum resulted in little if any decrease in yield.

If the stand is too thin, the plants tend to branch and set pods nearer the ground level, causing harvest difficulty and higher harvest losses. See Table 3 for information on optimum plant stands and seeding rate necessary to get them.

Estimates in Table 3 are based on using high quality, well-screened seed having a germination of 85 percent or higher. In general, in rowed beans, the optimum rate is 10 to 12 seeds per foot of row resulting in 8 to 10 plants.

The seeding rate per acre is shown as seeds per foot of row because the normal seed size of soybean varieties differs considerably. A pounds-per-acre rate for one variety would be incorrect for another. For example, using the Harosoy 63 variety in 28-inch rows, about 70 pounds of seed per acre would be required; with Chippewa 64 about 60 pounds per acre would be correct. How the seed is screened can make a significant difference in pounds of seed required. The suggested seeding rates given below may serve as a rough guide:

Row width (inches)	Pounds per acre
7 (drilled)	100-120
14	90
18-21	80-90
28	60-70

Seed size affects the planting rate. Information furnished in Table 4 shows approximate numbers of seeds per pound of some of the current recommended varieties. These data were obtained from counts of seeds in certified seedlots. Common seed may vary from these figures and different certified seedlots will vary to a lesser degree. Seedlots will vary some from year to year in terms of seeds per pound even though the same screening procedures were used each year.

Table 4. Seeds per pound of 4 soybean varieties.

Variety	Approximate seeds per pound
Chippewa 64	3,000
Hark	2,700
Harosoy 63	2,400
Amsoy	2,600

WEED CONTROL

Adequate weed control remains one of the foremost problems in soybean production. Some of the ways in which weeds affect the crop are:

1. Lower yields
2. Increase lodging
3. Shorten plants
4. Harbor of insects and diseases
5. Delay maturity
6. Cause harvest problems

Weed control is a complete rotation problem, rather than one of any particular crop. A variety of things may be done to decrease the weed population. While not listed as weeds, volunteer corn plants from last year's crop are weeds in a field of soybeans and are most difficult to control. Careful corn harvest will help to reduce this problem.

An important factor in weed control is to kill the weeds early, as they begin to sprout. After planting and before the soybean seedlings emerge, a rotary hoe or similar equipment can be used to break a crust and kill small weeds. This type of equipment may be used until the soybean plants are 4 to 6 inches tall. Essential to a good job is to attack when the weeds are in the "white" or just coming through the ground, and to operate at a high speed. Do not worry about damaging a few soybean plants. Do not use the hoe when soybean plants are in the "crook" stage.

If a rotary hoe or similar equipment is not available, cultivate early and carefully to get the weeds and avoid covering the bean plants. Cultivation should be mostly shallow and level as ridging may cause difficulty in harvest.

Herbicides for use with soybeans have improved in the past 5 years. They are especially valuable in early weed control. However, in most Michigan fields the present herbicides are not reliable enough year after year and some other control is needed to supplement their work. Early in the season, when wet weather may prevent the use of a rotary hoe or other mechanical equipment, a herbicide will frequently do an excellent job. Herbicides are especially useful on large acreages.

Most herbicides may be used broadcast or banded to reduce the cost. If banded, the middle of the rows must still be cultivated. For success with herbicides, soil moisture must be adequate to support good plant growth. With pre-emergence herbicides, ¼ to ½ inch of rainfall is needed to move them into the top ½ inch of soil to be effective.

Specific current recommendations for herbicide use in soybeans are given in MSU Extension Bulletin E-434, Weed Control in Field Crops.

While both mechanical and chemical means of weed control will work, more often a combination of the methods results in the best and most economical control.

HARVEST AND STORAGE

For highest quality and yield, soybeans should be harvested as soon as weather conditions permit after they reach a moisture level of 14 percent or less. Frequently, the best harvesting conditions occur just after the first frost. This frost kills the plants and weeds and causes them to dry. Further delay in harvesting may mean lower quality and higher harvest losses due to shattering and lodging. Figure 4 shows a comparison of weather damaged, and high-quality beans. Local elevators are equipped to run a moisture test on samples as a guide to determining the proper time to begin harvesting.

Common harvesting losses are:

- Shattering before combining
- Beans missed, or pods cut through by the combine cutter bar
- Failure to thresh beans from pods
- Splitting and cracking beans
- Failure to separate beans from chaff
- Beans blown over the chaffer extension with chaff.

Cylinder speeds ranging from 400 to 800 RPM are normally adequate. Cylinder-concave clearances of 5/16 to 7/8 inch usually give good results. Use only enough concave bars or teeth to thresh the beans from the pods. Considerable fan blast is necessary, and the adjustable chaffer and chaffer extension should be at least ⅔ open, with the sieve about ½ open.

An operators' manual provided with the combine gives basic information on adjustments for that particular make and model of machine. These instructions are usually for normal conditions, and cannot cover all situations. They should be used as a guide,

Fig. 4 — Effect of delayed harvest on quality of soybeans. Left—weathered, damaged beans. Right—good quality beans.

and additional adjustments made to solve special problems. Care in threshing is very important in producing seed for planting the next year.

Every 4 to 5 beans left in the field per square foot of land means a loss of about 1 bushel per acre. Cracked or split beans, and beans with a cracked seedcoat will result in a high screening loss and lower quality.

Shattering losses occur before combining, and increase as the soybeans lose moisture and dry out. Timely harvest helps to reduce these losses.

Cutter bar losses may be reduced by selecting taller varieties (if available) and varieties with more lodging resistance; more complete weed control; and avoiding ridging of the beans when cultivating.

Cylinder losses may be held to a minimum by properly adjusting cylinder speed and cylinder-concave clearance. Use only enough concave bars or teeth to thresh the beans from the pod. Over-threshing at the cylinder will result in splitting and cracking of beans, and damage to the seedcoat. Use only enough threshing action to thresh the beans out of the pods.

Straw rack losses are usually small, but may be excessive if the proper rack speed is not maintained. Overloading of the combine, caused by excessive ground speed for operating conditions also may result in excessive losses.

Cleaning shoe losses may be held to a minimum by proper adjustment of the chaffer, the chaffer extension, and the cleaning sieve. The amount and direction of the fan blast through the cleaning shoe is also important. In general, use as much fan blast as possible without blowing beans out the back end of the machine. Direct most of the fan blast toward the forward ⅓ of the chaffer. Always use enough fan blast to maintain a "live" chaffer.

REMEMBER: a proper combine setting at 11:00 A.M., may not be correct for 2:00 P.M., of the same day. Figure 5 shows the effect of harvest on the quality of soybeans.

At times during the day the beans may be so dry, or the humidity so low as to cause excessive cracking or damage. The usual solution is to stop combining during the hottest and driest part of the day.

Store soybeans in clean, tight bins at a moisture content of 14 percent or below. Check the beans frequently for heating and move them to other bins if heating is detected. Drying with heated air may be advisable if the moisture content is too high; however, this operation is more difficult than drying corn. Anyone interested in drying soybeans should consult with the manufacturers of drying equipment and/or the Department of Agricultural Engineering, Michigan State University, for proper drying procedures and precautions.

INSECT CONTROL

Insects sometimes cause difficulties in soybean production in Michigan. Weeds and diseases more commonly cause trouble than do the insects. Sometimes insects contribute to the basic problem by being a carrier for diseases.

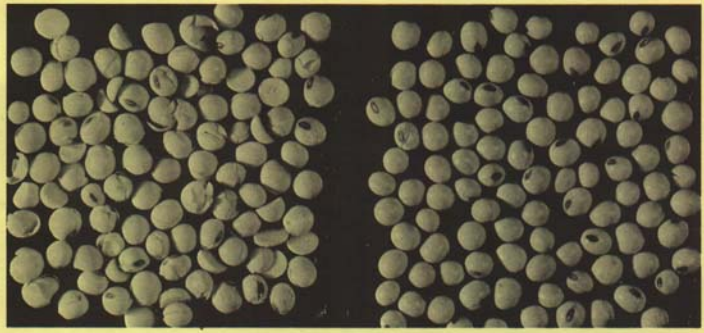

Fig. 5 — Effect of harvesting on the quality of soybeans. Left — poor quality (harvest damage). Right — good quality

A description of soybean insects and control measures may be found in MSU Bulletin E-499, Insect and Nematode Control in Field Beans, Soybeans, and Sugarbeets.

DISEASE CONTROL

Diseases of soybeans are caused by viruses, bacteria, and fungi. They have been increasing in frequency and importance in Michigan because of the rapidly expanded acreage and because successive plantings of soybeans appear more frequently in rotations. Extensive damage has been reported in some fields while in others diseases have had little effect on yield and quality. However, with wider crop usage, disease problems are likely to increase.

Weather, soil conditions, cultural practices, and seed have an important bearing on the severity of infection and spread of soybean diseases. Most diseases affect the above-ground parts of the plant; however, some affect the roots, thereby inducing water and nutrient deficiencies in the above-ground plant parts. For example, poor drainage and lack of adequate soil aeration favor diseases that attack the underground portions of the plant.

Although planting resistant varieties is one of the best methods of control, certain management practices will help reduce disease development. These practices include:

(1) planting high quality disease-free seed
(2) using a 3- or 4-year crop rotation
(3) planting soybeans in well-drained soil
(4) plowing under all crop debris in the fall
(5) preventing weed growth in and around the edges of the field
(6) avoid cultivating when plants are wet.

Virus Diseases

BUD BLIGHT

This disease is the most important virus disease in Michigan. It is caused by the tobacco ring spot virus (TRSV). Symptoms vary with the stage of development at which plants are infected. When young plants are infected before flowering the stem tip turns brown, curves downward and becomes dry and brittle. This injury is shown in Fig. 6A.

The young leaves may have a rusty appearance. Sometimes the inside of the stem below the blighted bud is discolored, often at the nodes. Plants may be stunted and podless. If pods do develop the seeds could be infected and the disease could then be transmitted through them. See Fig. 6B for appearance of distorted young leaves and inner stem discoloration at the nodes.

Infection prior to or at the time of flowering results in the development of small and undeveloped pods. Infection after flowering results in poorly filled pods with a distinctive dark or purple blotching. Diseased plants can be recognized late in the season because they remain green after normal plants are mature or until a killing frost occurs.

The disease usually appears first at the border of a field near weed pastures, grassy and weedy drainage areas, or near legume-grass hay fields. Once established, the disease may spread rapidly into the field indicating that insect vectors are carrying the

Fig. 6A — Bud blight-infected soybean plant showing distorted terminal leaves curving downward. (Courtesy of Illinois Agricultural Experiment Station).

Fig. 6B — Bud blight-infected soybean plant showing distorted young leaves and discolored inner portion of stem at nodes. (Courtesy of Illinois Agricultural Experiment Station).

virus. Keeping bordering areas free from weeds and other plants that may harbor the virus should help reduce the infection. In southwestern Michigan some serious infections have occurred. In general this area has more fence rows, forage fields, and brushy areas than other production areas. The nematode *(Siphinema americanum)* can harbor and transmit this disease.

SOYBEAN MOSAIC

Soybean mosaic is caused by *Soja virus 1.* The leaves on the infected plants may be dwarfed, wrinkled or have dark-green puckered areas between the veins. Leave symptoms may resemble 2, 4-D injury. The petioles and internodes may be shortened, and the pods stunted. The virus is seed-transmitted and spread in the field by aphids.

YELLOW MOSAIC

Yellow mosaic is caused by *Phaseolus virus 2.* The leaves of infected soybeans develop a distinct yellow mottling. This disease is not seed-borne but is transmitted by aphids from infected weeds and legumes bordering the soybean field.

Bacterial Diseases

BACTERIAL BLIGHT

Bacterial blight, a common disease in Michigan, is caused by *Pseudomonas glycinea.* Its first symptoms are small angular brownish-black spots on leaves. Older spots have a sunken appearance and are bordered by a narrow yellow band on the top side of the leaf. Wind whipping may cause the diseased leaf tissue to drop out giving the leaf a shot-holed appearance. See Fig. 7.

BACTERIAL PUSTULE

Bacterial pustule is caused by *Xanthomonas phaseoli* var. *sojensis.* The first symptoms appear as a small yellowish-green area with a reddish-brown center and a raised pustule. Infected areas usually coalesce resulting in larger dead areas. These dead areas may fall out leaving an irregular hole.

The causal bacteria are seed-borne and overwinter in crop residue. Infection occurs when the bacteria are splashed from the soil to the leaves where they enter natural openings, multiply and destroy the leaf tissue. Wet weather favors disease development. Be-

Fig. 7 — Bacterial blight of soybeans showing angular, brownish spots on leaves and shot-holes caused by drop out of dead tissue. (Courtesy of Illinois Agricultural Experiment Station).

cause the varieties recommended for Michigan are fairly susceptible, it is important that the control practices listed earlier be followed.

Fungus Diseases

ROOT ROTS

Root rots are caused by species of *Phytophthora, Fusarium, Rhizoctonia* and *Pythium*. These fungi cause pre-or post-emergence damping-off and seedling blight, or wilting and death of the plant at any later stage. The best control for all is to plant good quality seed in well-drained, warm soil.

Phytophthora root rot — Root rot caused by *Phytophthora megasperma* var. *sojae*, devolops rapidly in the roots and stems of infected seedlings, often resulting in early death. The first symptoms on older plants are yellowing and wilting of leaves, and a dark brown discoloration of the stem, which extends from below the soil line upward into the stem. The taproot is usually dark brown and branch roots may decay.

This disease is common in low, poorly drained areas but may appear on higher ground in wet seasons. Damage is more severe on heavy clay soils. Frequently successive plants are killed in a row leaving wide gaps.

The best control for this disease is to plant resistant varieties. Chippewa 64, Harosoy 63 and Lindarin 63 are highly resistant.

For current recommendation refer to Mimeograph File 22.17, Soybean Variety Comparisons in Michigan. Do not plant susceptible varieties on land where this disease has been known to occur.

Fusarium root rot — This disease is usually confined to the roots and lower portions of the stem. The fungus gains entrance through rootlets and invades the stem through the pith. When infection is severe, wilting sometimes occurs from lack of moisture. Mounding soil around the base of infected plants during cultivation will encourage root development above the diseased portion of the stem. Excessive soil moisture, soil compaction and other factors that restirct soil aeration favor the development of this disease.

Rhizoctonia root rot — This disease is caused by *Rhizoctonia solani* and results in a reddish-brown decay of the outer layers of the root and basal stem. Girdling of the stem may follow. While the fungus

is generally restricted to the upper 2 or 3 inches of soil, it may proceed lower into the taproot and even into the secondary root system. Rhizoctonia tends to kill plants in roughly circular areas extending 4 to 10 feet in diameter and scattered irregularly over the field. Root rot development is most pronounced in wet soil.

BROWN STEM ROT

Brown stem rot results from infection by *Cephalosporium gregatum*. Infection usually takes place through the roots and spreads to the lower stem, causing the plant tissue to turn brown and sometimes split. The lower and sometimes the upper leaves will turn yellow and brown between the veins. With severe infection the leaves may wilt and die as shown in Fig. 8.

Leaf symptoms are not always present. When present they may be a result of another disease or a nutrient deficiency. The brown pith, observed when the stem is open, is a distinctive symptom.

The casual organism over-winters in bean residue and in the soil. The disease is favored by cool weather and is most likely to appear in August.

Crop rotation with 3 or 4 years between soybean crops and complete plow-down of plant residues are effective practices in reducing infection. There are no resistant varieties. Plants weakened by disease usually produce smaller than normal seeds.

SCLEROTINIA STEM ROT OR WHITE MOLD

The fungus *Sclerotinia sclerotiorum* is the cause of this disease. It may appear as a white cottony growth at the base of the stem. Stem tissue may be destroyed and the plant will usually die before pods are formed. Black, irregularly shaped bodies about ⅛ to ¼ inch in diameter may be seen in the white fungus mass or within the dried stem. These are resting bodies (sclerotia) of the fungus. During the summer, the sclerotia germinate and produce small fruiting bodies from which spores (seeds) of the fungus are discharged into the air. The spores land on the plant parts and infection occurs when sufficient moisture is available for their germination. The fungus is soil-borne. The sclerotia are highly resistant to cold, heat, and chemicals and can live in the soil for many years.

Deep plowing is probably the most effective control measure. This disease can be very damaging. It also affects field beans, so soybeans should not follow field beans in the rotation.

STEM CANKER

Stem canker is caused by the fungus *Diaporthe Phaseolorum* var. *caulivera*. Brown sunken lesions appear near the base of the stem and at the nearby nodes. Often the stem is girdled, resulting in death of the plant from the lack of water and nutrients.

The pathogen is seed-borne and it over-winters in bean residue. The disease usually appears in early July on young plants and plants are often killed in their later stages of development. The appearance of dead plants with dried leaves still attached may be the first symptoms of the disease.

A 3- to 4-year crop rotation, deep plow-down of soybean residue, the use of disease-free seed, and seed treatment are recommended in the control of this disease. Harosoy 63 has some resistance.

BROWN SPOT

Brown spot is a common disease of soybeans in Michigan. It is caused by the fungus *Septoria glycines*. Typical symptoms are the production of reddish-brown spots on the leaves. With severe infections the spots join and the leaves yellow and drop prematurely. Stem and pods may show infection late in the season.

Fig. 8 — Brown stem rot of soybeans showing the brownish interveinal leaf discoloration. (Courtesy of Illinois Agricultural Experiment Station).

The pathogen survives in infested soybean tissues and to some extent in the soil. The disease appears early in the season and is favored by low temperatures and abundant rainfall.

Crop rotation combined with deep plow-down of bean residue is effective control.

DOWNY MILDEW

This disease is caused by *Peronospora manshurica*. Infected leaves show distinct yellow spots on the upper surface and a grayish mold opposite the spots on the lower surface of the leaves. As the spots enlarge

they join, turn brown, and the leaves wither and die. The seeds and interior of the pods may become infected and covered with a grayish mold.

The pathogen over-winters on the seed and in infested bean tissues. Seedling infection can occur locally from fungus spores on the seed. Downy mildew is a cool weather disease. It occurs on heavy soils during periods of high humidity and good soil moisture. All varieties are susceptible.

PURPLE SEED STAIN

Purple seed stain is caused by the fungus *Cercospora kikuchii*. This fungus attacks leaves, stems and pods but is most conspicuous on the seedcoat as a purplish blotching. A dull-brown discoloration of the seed caused by *Alternaria* infection should not be mistaken for purple seed stain. Since the fungus is seed-borne, disease-free seed should be planted. The recommended control practices listed earlier should be followed.

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