Field Bean Production in Michigan
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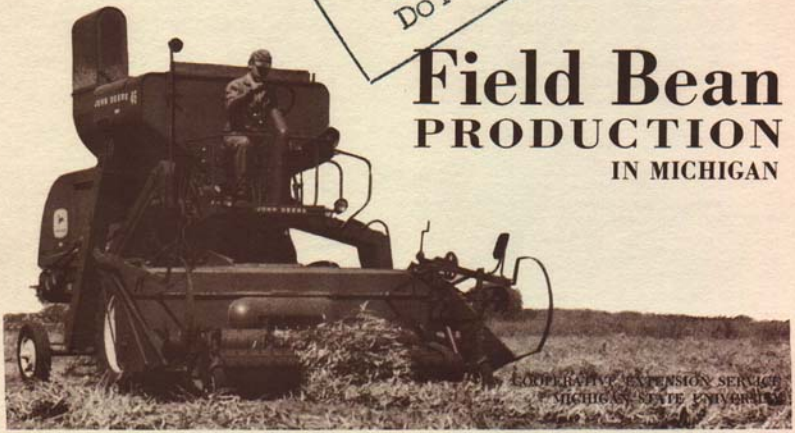

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APPROXIMATELY one-third of all the edible dry beans produced in the United States during the period 1954-63 were grown in Michigan. The average acreage of field beans harvested in Michigan during this period was 515,000, with an average acre yield of 1,108 pounds. The Michigan bean crop returned $37,957,000 annually to Michigan bean farmers. Beans rank third in value of Michigan field crops.

BEAN CLASSES AND USES

Most of the field beans in Michigan are of the navy (pea) bean type. An average of 5,318,000 bags out of a total of 5,798,000 (100-pound bags) were produced annually during 1954-63. Michigan farmers, in recent years, have produced more than 98 percent of the navy beans grown in the United States. Other bean types grown are red kidney, cranberry, yellow-eye, pinto, and small red.

The canning industry uses most of the Michigan-grown navy and red kidney beans. More than 90 percent of the navy beans consumed in the United States are canned. Canners like the navy beans because they remain whole and retain their form in the can after processing.

The class of dry beans preferred by the consumer varies with the section of the country. Cranberry beans are consumed in the mining regions of the southeastern United States. Yelloweyes are favored in New England, and pinto beans by the people of Mexican descent in the southwestern United States. Navy (pea) beans have a wide market across the country and, in recent years, up to 25% of the navy beans produced in Michigan have been exported.

Field beans are most productive on well-drained, fine-textured soils, but are also grown on sandy-loam soils. Sandy soils should be well supplied with organic matter for best results. The bean plant is sensitive to both excess water and drought. Tile drainage is essential on the fine-textured bean soils in Michigan if top yields are to be obtained.

Navy bean production in Michigan is concentrated on the fine-textured lake bed soils of the Thumb and Saginaw Valley areas. Some colored beans are also grown on these soils, but much of the colored bean acreage is located on sandy-loam soils in west central Michigan.

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Field beans are not grown in extreme southern Michigan because of the greater probability that high temperatures at blossom time will result in poor pollination, reduced "pod set," and low yields.

In much of northern Michigan, prior to the recent development of earlier maturing varieties, the growing season was too short for beans. Early varieties now available will mature before fall frost. Later maturing varieties mature in areas in northern Michigan close to the Great Lakes.

ROTATIONS

Field beans respond well to green manure crops in a rotation. Beans following barley seeded to a clover green manure crop yielded an average of eight bushels more per acre than beans following barley without a green manure crop in 6 years of experiments conducted at the Ferden farm by the Soil Science Department. Beans can be grown in a wide variety of rotations, but fit especially well after alfalfa, clover, corn, or small grain crops seeded to a legume green manure crop. Many bean producers grow sugarbeets, and generally follow a crop sequence in which the beans follow alfalfa or clover plowed down, with the sugarbeets following the beans. The Ferden farm rotation experiments show that this sequence gives the best yield of both beans and sugarbeets. Beans should not follow directly after beans in the rotation because of the danger of increased disease infestation, and at least 2 years between bean crops is desirable. Both blight and anthracnose organisms may live on dead plant material in the soil for 1 to 2 years.

SOIL PREPARATION

The moldboard plow is the most effective tillage tool where weeds or crop residues are problems, or where the soil has been compacted as a result of excessive tillage or poor drainage. The best plowing is possible only when the plow is properly adjusted and when soil moisture conditions are favorable for maximum fragmentation. If the soil turns over in large clods, or if it is not possible to completely cover the trash and crop residues, it will be advantageous to pull a secondary tillage tool behind the plow. If after doing this the soil is still cloddy, it may be necessary to work the soil an extra time. The number of tillage treatments should be kept to a minimum to prevent excessive compacting of the soil.

The seedbed should be firm, but the soil between the rows should be loose and porous. It may be desirable when planting to use weights on the press wheel and to use small seed press wheels behind the planter shoes.

Fall plowing may be advantageous in fields that have been compacted to a great depth, but under average conditions a cover crop system with spring plowing is preferred. Where fall plowing is practiced, tillage before planting should be kept to a minimum.

In recent years, wind erosion has been a serious problem, especially in fall-plowed sandy areas. Excessive tillage in the spring accounts for some of this. Sowing strips of a small grain tends to reduce erosion severity.

Field cultivators are effective tillage tools (1) if used when the soil moisture level is low, (2) if used to control quackgrass, and (3) where no organic matter is to be incorporated into the soil.

An alfalfa or clover green manure crop ahead of beans normally should be plowed down by May 15. Plowing at a later date frequently results in excessive moisture depletion and lower yields in years when spring rainfall is below normal.

FERTILIZATION

A 30-bushel bean crop contains in the seed and straw approximately 90 pounds of nitrogen, 12 pounds of phosphorus, 50 pounds of potassium, 40 pounds of calcium, 6 pounds of magnesium, and 6 pounds of sulfur. Because bean plants are relatively shallow rooted, high soil fertility levels are important.

Soils used for bean production vary greatly in fertility and in their ability to supply nutrients. Fertilizer recommendations are based upon soil test results, the kind of soil upon which the crop is to be grown, the rotation, and the yield goal.

Beans respond best to fertilizer placed in a band 1 inch to the side and 2 inches below the seed. The crop is very susceptible to damage if the fertilizer is placed close to or in contact with the seed.

Extra nitrogen may be needed, depending upon the use of livestock manure and upon the crop sequence. The total nitrogen requirements for a 30-bushel crop are shown in Table 1. The rates shown in this table include the nitrogen that might be plowed down, plus the nitrogen in the plantingtime fertilizer, plus that which might be side-dressed.

TABLE 1. TOTAL NITROGEN FERTILIZER NEEDS FOR BEANS.

Use of legume and manure*	Pounds per acre of nitrogen
Good legume and 8 tons per acre of manure	10
Legume only — no manure	10
8 tons per acre of manure	20
No legume — no manure	40

*Assume 4 pounds of available nitrogen per ton.

On neutral or alkaline soils beans frequently need manganese. Use 5 pounds per acre if it is banded with the fertilizer at planting, or 10-20 pounds when broadcast ahead of planting.

Zinc deficiency may occur on alkaline soils, especially in the thumb area of Michigan. This problem is most intense on spoil areas near ditches and over tile lines where calcareous subsoil has been mixed with the surface soil and where a high rate of phosphate was used on the previous crop. Zinc deficiency is relatively common where beans follow sugarbeets on soils with high pH levels. The deficiency is due to the high amount of phosphorus applied for sugarbeets.

Figure 1. Beans need micronutrients on some soils. Four rows with poor growth — Sanilac variety without zinc.

Fertilizer containing 3 to 6 pounds of zinc per acre prevents the deficiency from developing. Where zinc deficiency is not clearly indicated, one pound of zinc per acre is suggested as a preventive program. These rates apply only to those materials classed as "mineral." In contrast, zinc in "organic" forms, such as the chelates, has increased yields when used at much lower rates—0.4 and 0.8 pounds per acre. Some of the chelates may be toxic if used in excess of one pound per acre of zinc.

VARIETY SELECTION

Factors a grower should consider when selecting a bean variety, or varieties, include: (1) plant type, (2) maturity, (3) disease resistance, (4) yield record, and (5) market quality. Seed of five navy bean varieties has been released to growers in the last 8 years by the Michigan Agricultural Experiment Station (Crop Science Department) and the U. S. Department of Agriculture cooperating. Growers with a substantial navy bean acreage probably should plant more than one variety so as to spread the risk of adverse weather at blossom time and to spread the harvest period.

Figure 2. A certified field of bush navy beans in the Thumb of Michigan.

Table 2 gives the characteristics of the recommended navy bean varieties for Michigan. All the varieties are susceptible to bacterial blight. The bush types are less subject to whitemold (Sclerotinia) because of better air circulation around the plants. The bush varieties hold their pods off the ground better than the vine-type beans, so are less susceptible to weather damage after maturity and generally have a lower "pick." A period of hot, dry weather during blossoming may substantially reduce pod set on bush varieties, whereas the vine types will continue to blossom and set pods.

The bush varieties are best adapted to the productive, fine-textured (heavy) soils in the main bean producing areas of the Thumb and Saginaw Valley, where over 90 percent of the beans now planted are bush varieties. The vine-types are best adapted to the less productive or sandier soils.

Comparative yields of the recommended varieties are given in Table 3. Note the reduction in yield of the vine-types (Saginaw and Michelite 62) where white mold was present.

TABLE 2. CHARACTERISTICS OF NAVY BEAN VARIETIES.

Variety	Plant type	Approximate Days to Maturity	Resistance* Disease
Seaway	Bush	80-90	V-1, V-15
Sanilac	Bush	85-95	V-1, A
Gratiot	Bush	85-95	V-1, V-15, A
Saginaw	Vine	88-98	V-1, V-15, A
Michelite 62	Vine	90-100	V-1

*V-1 —Strain 1 mosaic
V-15—Strain 15 mosaic
A —Anthracnose

TABLE 3. YIELD (IN CWT. PER ACRE) OF NAVY BEAN VARIETIES.

Variety	Research Plots (Average of 4 years Saginaw & Gratiot Cos.) Cwt. per acre	County Trials (Average of 15 Trials, 1960-61)*
Seaway	19.0	18.7
Sanilac	21.4	19.9
Gratiot	19.6	19.1
Saginaw	20.1	17.4
Michelite 62	18.8	16.4

*White mold (Sclerotinia) was severe at 2 of the 15 locations. Yield of the vine-type varieties was reduced by white mold to a much greater extent than that of the bush varieties.

COLORED BEANS

Growers of colored beans do not have a wide choice of varieties. Only one named variety, Charlevoix, has been released to Michigan growers. Charlevoix is a dark red kidney bean resistant to two races of bean anthracnose.

In addition, there is a common Michigan Dark Red Kidney and a California Dark Red Kidney. The common Dark Red is several days later maturing than Charlevoix, and the California Dark Red is 7 to 10 days later than the common Michigan type. Growers should avoid late planting of the California Dark Red Kidney on fields subject to early frosts. Seed of common Michigan Dark Red Kidney grown in California is labeled **"Dark Red Kidney — California grown,"** whereas the California type is labeled **"California Dark Red Kidney — California grown."**

Other colored beans grown in Michigan are commercial types, without variety designation. Table 4 compares colored bean types. All types are susceptible to common blight.

TABLE 4. CHARACTERISTICS OF COLORED BEAN TYPES.

Bean	Growth habit	Approximate Days to Maturity	Disease comments
Dark red kidney	Bush	90-105	Charlevoix variety resistant to Races 1 and 2 of Anthracnose.
Light red kidney	Bush	95-105	
Cranberry	Vine & bush	95-110	
Yelloweye	Vine	90-100	Resistant to Halo blight
Pinto	Vine	90-100	Resistant to Halo blight

Some difficulty has been experienced in recent years with a late strain of cranberry bean from California. This strain flowers at the time the common commercial type is maturing, and has not matured in Michigan in any season to date. Seed of this late strain has not carried a special identifying label. Michigan seedsmen may eliminate this problem by using extreme care in procuring cranberry bean seed from California.

SEED QUALITY

High quality bean seed has high germination, carries little or no disease, is pure as to variety, and is uniformly sized. Use certified seed to be assured of obtaining seed with these qualities.

Bean seed is highly susceptible to both seedcoat damage and internal injury. Beans with checked seedcoats (the seedcoat has a crack or break) have both a lower germination and reduced seedling vigor. Beans without apparent seedcoat damage, from seedlots with checked seedcoats, may have internal injury, resulting in both lower germination and reduced germination vigor. (See Table 5.) So seedlots containing any appreciable percentage of checked seedcoats should be avoided.

Blight, anthracnose, and common bean mosaic all may be seed borne, but infected seed may be indistinguishable from non-infected seed. Disease symptoms can be seen on the growing plants. Fields are inspected in the certification process and those carrying disase are rejected, thus providing greater assurance of disease-free seed. Some bean varieties are resistant to anthracnose and mosaic, but all are susceptible to blight. Planting blight-free seed is an important control measure for this major bean disease.

SEED TREATMENT

Chemical seed treatment protects bean seed and seedlings from seed decay, or damping-off, caused by soil fungi (molds), and from the seed-corn maggot. Damage from both soil fungi and the seed-corn maggot is most severe in cold, wet soils.

TABLE 5. INTERNAL INJURY IN SEED WITHOUT SEEDCOAT DAMAGE, BUT FROM SEEDLOTS CONTAINING BEANS WITH CHECKED SEEDCOATS.

Description of Injury	Number of Seedlings	% Total
Normal seedlings	15,523	78.78
Loss of one cotyledon	2,384	12.10
Loss of both cotyledons	5	0.03
Loss of one primary leaf	27	0.14
Loss of both primary leaves	37	0.19
Loss of terminal bud (baldheads)	1,727	8.76

To protect the bean seed and seedling from this damage, seed should be treated with a mixture containing either thiram or captan as the fungicide, and dieldrin as the insecticide. Buy treated seed rather than treating on the farm. Treated seed must be stained with a contrasting color as required by the Michigan seed coloring law.

INOCULATION

Inoculation of bean seed with nitrogen-fixing bacteria has not given a beneficial effect. A number of tests have been conducted in Michigan and elsewhere in which no significant advantage in yield has been obtained from seed inoculation. Field beans nodulate freely, without inoculation, in most Michigan soils.

ROW WIDTH

Most of the field beans grown in Michigan are planted in 28-inch rows. In one series of tests with bush-type varieties, yields from 24-inch and 28-inch rows were practically the same. (See Table 6.) In another test comparing several varieties in 24-inch, 28-inch, and 32-inch rows, all varieties gave the highest yield in 32-inch rows and the lowest in 24-inch rows. (See Table 7.) White mold was more severe and reduced yields more in the narrower row widths. The vine-type varieties (Saginaw and Michelite) were more severely damaged by the white mold than were the bush-type (Sanilac, Seaway, and Gratiot). Air circulation around plants is effective in reducing white mold. A third test compared 28-, 32-, and 36-inch rows. (See Table 8.) Differences in yields were not large, but the 28-inch row width gave the highest yields.

SEEDING RATE

The optimum seeding rate is influenced by a number of factors, including the quality of the seed and soil conditions. Higher than normal rates will be required for seed with poor germination, due to checked seedcoats or other causes, and when soil conditions favor crusting. Seeding rates should also be higher than normal when the rotary hoe and similar implements are used for weed control.

TABLE 6. YIELD (IN CWT. PER ACRE) OF SANILAC AND SEAWAY VARIETIES IN 24- AND 28-INCH ROWS.

Variety	Test Number	Row Width 24"	28"
Sanilac	1	14.8 cwt.	16.6 cwt.
	2	20.6	19.0
	Average	17.7	17.8
Seaway	2	16.2	16.0

TABLE 7. YIELD (IN CWT. PER ACRE) OF NAVY BEANS GROWN IN 24-, 28-, AND 32-INCH ROWS.

Variety	Row Width 24"	28"	32"
Seaway	18.7 cwt.	24.0 cwt.	24.5 cwt.
Sanilac	19.1	20.9	24.2
Gratiot	17.2	22.2	23.3
Saginaw	11.1	14.0	16.3
Michelite 62	8.8	12.7	13.9

TABLE 8. YIELD (IN CWT. PER ACRE) OF NAVY BEANS IN 28-, 32-, AND 36-INCH ROWS.

Variety	Row Width 28"	32"	36"
Sanilac	24.8 cwt.	23.2 cwt.	22.6 cwt.
Seaway	23.0	23.2	22.6
Michelite	23.9	22.8	22.8

Tests with vine-type navy beans showed 40 pounds of seed per acre to be the optimum seeding rate. Seed treated with an insecticide-fungicide combination at 35 pounds resulted in a stand equal to 40 pounds of untreated seed.

In a more recent test involving both bush and vine-type beans, seeding rates of 15, 22½, and 45 pounds per acre were compared (seed spacings of 6, 4, and 2 inches, respectively, in 28-inch rows). The 45-pound rate gave the highest yields, but the relatively low rates of 22½ and 15 pounds per acre yielded only 0.6 to 1.8 cwt. less per acre, respectively. In another experiment involving the Sanilac variety, bean *plants* were spaced at 2, 3, 4, 6, 9, 12, 16, 18, and 24 inches in the row. The highest yield was obtained with the 3-inch plant spacing.

With good quality seed and satisfactory soil conditions, there is no need for seeding more than 35 pounds of treated navy bean seed per acre. The recommended seeding rates for beans are as follows:

Navy (pea)	— 35 pounds per acre
Red Kidney beans	— 80 pounds per acre
Cranberry beans	— 60 pounds per acre
Yelloweye beans	— 60 pounds per acre

DATE OF PLANTING

Date of planting trials conducted prior to World War II indicated that June 1-10 was a desirable date for planting field beans. Comprehensive date of planting trials have not been conducted since the introduction of the bush varieties. Limited tests support the June 1-10 date of planting, except that the early maturing Seaway variety yields well with later planting — up to June 25. Because root rots are more damaging at cool temperatures when beans are growing slowly, May planting is generally not desirable.

WEED CONTROL

Field beans are sensitive to weed competition. Cultivation alone may give adequate weed control in some years; in other years, herbicides or hoeing are also required for satisfactory weed control. The extent to which weeds reduce bean yields was illustrated in tests where cultivation plus hoeing increased yields over cultivation alone by 384 pounds per acre in one year and by 732 pounds per acre in a second year.

An effective and efficient method for control of annual weeds is by use of either pre-planting or pre-emergence herbicides. Use of such herbicides is especially recommended on fields known to have a weed problem. Band application will reduce herbicide costs. Refer to Extension Bulletin #434, "Weed Control in Field Crops," for recommendations.

Figure 3. Cultivating beans. Weed control is important in bean production.

Weeds are controlled easiest when small. Use of the rotary hoe, spike-tooth harrow, or weeder just after the weed seeds have germinated is a fast and effective method of weed control. These implements normally are first used 2 to 3 days after the beans are planted and until the beans are 4 to 5 inches tall. Only 1 or 2 regular cultivations may be required when the rotary hoe, or similar equipment, is used 2 or 3 times. Beans are more easily injured by these tools when the plants first emerge and still have the crook in the stem than immediately after this stage. These implements are also less likely to damage beans if used in the afternoon when the plants are less turgid and brittle. Weed control with these tools is most effective on fields free of stones and with a mellow surface. When soil crusting occurs before emergence of the beans, these implements can be used to break the crust and thus aid in the emergence of the bean seedlings.

Between-the-row cultivation should be shallow so the roots will not be injured. Deep late cultivations can be especially damaging. In tests over a 4-year period, 3 to 4 deep cultivations reduced bean yields 174 pounds per acre compared to 3 to 4 shallow cultivations.

Beans should not be cultivated when plants are wet from dew or rain. Blight and other diseases are more easily transmitted from one plant to another when plants are wet.

DISEASES

Diseases are a major problem in bean production, with growers sometimes having serious losses. Blight is the most serious disease of beans, but other diseases also give substantial losses.

Bean diseases can be held to a minimum through use of the following practices: (1) Plant disease resistant varieties — if available; (2) Use disease-free seed (certified seed is recommended); (3) Use a rotation with 2 or 3 crops between bean crops; (4) Do not work in bean fields when the plants are wet; (5) Plow under bean refuse; (6) Treat the seed to prevent damping-off and seed decay, as well as seed corn maggot injury.

Details regarding the symptoms, methods of transmission, and control measures for the most common bean diseases are given in Table 9.

INSECTS

Field beans are affected by a number of insects; the most important insects and symptoms of their damage are as follows:

Seed Corn Maggot: The seed fails to sprout, or sprouted seedlings are weak and sickly. Often dirty-colored (yellowish-white), legless, tough-skinned maggots bore in the seed. These have a pointed head and reach one-fourth inch long when mature.

The seed corn maggot is most damaging in damp soils with high organic matter. The adult egg-laying female flies are strongly attracted to rotting organic matter and freshly plowed soil. Plow manure and sod under thoroughly.

Wireworms: The bean seed often fails to germinate. The germ of these seeds are eaten or the seed is hollowed, leaving sometimes only the coat. Smooth-skinned, dark-brown to yellowish, hard-bodied, wire-like worms (up to 1½ inches long), occur in the seed or in the soil surrounding it.

Cutworms: Dead and wilted plants occur in stretches of rows or over the field in scattered spots, especially in the morning. Thick-set, greasy-appearing, curve-bodied, thick-skinned, yellowish, greenish or blackish worms may be found near or up to a

foot away from damaged plants. These insects are usually found buried at least an inch in the soil during the day. They feed mostly at night and occur on the surface of the soil at this time. Late afternoon, early evening, or night observations are best to locate the insects.

Flea Beetles: Small holes (shot holes) are eaten through the leaves by the adult flea beetles. In severe cases, the leaves and buds may be entirely destroyed. Small brown, black, or striped jumping beetles do the damage.

Bean Aphid: These insects are small (up to 1/12 inch long), nearly black in color and have long slender legs. Near the tip-end of the body, two slender tubes project backward. When wingless they feed in clusters on the underside of the leaves, along the stems, or in the buds. In addition to the wingless forms, some individuals may be winged; these usually are scattered over the plant. Aphids have sucking mouth parts and inject mosaic-type viruses into the bean plant.

Green Cloverworm: The green cloverworm chews circular or ragged-edged holes in the leaves. In some cases the leaves are entirely eaten and blossoms may be devoured. Various-sized worms (up to 1¼ inches long) occur on the underside of the leaves. These are slender and light green in color. Faint white lines run lengthwise of the body. When disturbed, they wiggle and drop quickly to the ground. The green cloverworm is seldom important on field beans in Michigan but when it does occur, damage can be severe.

Mexican Bean Beetle: Early in the growing season, the adult beetle chews holes in the leaves. The adult Mexican bean beetle is copper-brown, ¼ inch long, and has 8 small black spots on each upper wing. It is in the same insect family as the lady beetles, so it resembles them. Later in the season, a yellow-spiny grub eats the skin off the under side of the leaves, causing them to feather or appear sieve-like. Eventually damaged leaves turn brown. If pods are on the plant, they may be damaged by feeding punctures.

Leafhoppers: These insects are up to 1/8 inch long, wedge-shaped, green to greenish-yellow in color, and winged or wingless. The leafhoppers have sucking-type mouth parts and occur mainly on the underside of the leaves. When disturbed, they often run sideways. Feeding by this insect dwarfs, curls, crinkles and rosettes the leaves, turning them brown, especially at the tips. This affects growth and pod formation and, consequently, yield.

For insect control measures, refer to Extension bulletin E 499, "Insect and Nematode Control in Field Beans, Soybeans and Sugarbeets."

HARVEST

Field bean harvesting operations usually include pulling, windrowing, and combining from the windrow. Grain combines equipped with bean attachments are frequently used, although special bean combines are available, and are used by growers with larger acreages. Bean attachments for grain combines usually include kits for cylinder speed reduction, seed and dirt screens, and other parts which vary with each make and model. Special cylinders, rubber-covered bars, and bean grates are available from some manufacturers. The spike-tooth cylinder has become quite popular. Bean combines usually have two cylinders specifically designed for bean threshing, and special separating and cleaning units.

Field beans should be harvested and handled at the 17- to 18-percent moisture level in order to hold splitting and seedcoat damage to a minimum. Harvesting at lower moisture levels may result in an excessive percentage of split beans and checked seedcoats. Beans with checked seedcoats may split with further handling. Beans with over 5 percent checked seedcoats may be difficult to market.

PULLING AND WINDROWING

Field beans may be pulled and windrowed in two separate operations, or as a single operation. Blade-type pullers are usually used to lift the crop from the soil. Pullers and windrowers are available as two-, four-, six-, and eight-row units. The number of rows to be placed in one windrow will depend upon the density of the crop and the size of combine used. Beans should be left in the windrow only long enough for the lower stem and attached root parts to dry sufficiently for combining. The bean windrower can also be used when necessary to relocate windrows on clean, dry ground following a rain. Bean plants should be placed in fluffy windrows, free of clods, stones, and dirt.

Figure 4. Combining beans from the windrow.

COMBINE OPERATION

Use only enough cylinder speed to do a good job of threshing. It is usually desirable to reduce the cylinder speed as the day progresses, to compensate for additional drying. Maintain as great a cylinder-concave clearance as possible, and still do a good job of threshing. Check the operator's manual for recommended cylinder speed and cylinder-concave setting. Manufacturers' recommendations apply to average, or normal operating conditions, and may have to be varied to meet specific field conditions. It may be necessary to harvest only in the morning and evening when the pods are tough, in order to hold shattering losses to a minimum, and to reduce the number of split beans and checked seedcoats. Crowd the combine cylinder to near-maximum capacity without over-loading. This may be accomplished by using a faster ground speed, or by placing more rows in the windrow. The additional straw going through the threshing mechanism will help to cushion the beans, and prevent damage.

Open the adjustable chaffer sufficiently for all threshed beans and some hulls to fall through to the cleaning sieve. Open the chaffer extension slightly wider to permit beans in pods to fall through to the tailings auger. Open the adjustable sieve only enough to let completely threshed beans fall through to the clean grain auger. Use a relatively strong fan blast, and direct the fan blast toward the forward one third of the cleaning shoe. Check the operator's manual for specific recommendations.

Check the tailings return periodically to note the quantity and composition of the material being returned to the cylinder for rethreshing. Any appreciable quantity of threshed beans in the tailings return indicates that the adjustable sieve or possibly the adjustable chaffer are too tightly closed. Completely threshed beans returning through the tailings auger for rethreshing will materially increase the possibility of split beans and checked seedcoats.

Check the grain tank for dirt and foreign material, and for beans that are split or have checked seedcoats. Excess dirt and chaff generally indicate that the adjustable sieve is adjusted too wide, or that the fan blast is inadequate or improperly directed. Excessive checks and splits generally indicate one of more of the following: (1) The cylinder speed is too high; (2) The cylinder-concave clearance is too small; (3) Too many concave bars or grates are being used; or (4) Too many completely threshed beans are being returned through the tailings system.

Always handle field beans carefully. Avoid dropping beans from great heights in unloading and handling. Beans check and crack when dropped, particularly on hard surfaces and when dry. Cushion or deflect fall of beans whenever possible. Keep elevator flight chains snug, so that flights ride true in the housing.

FIELD LOSSES

Check field losses carefully, and try to determine where losses are occurring. Depending upon variety, every 4 or 5 beans left in the field per square foot of land, equals a loss of about 1 bushel per acre. Split beans, and beans with cracked seedcoat will result in a high screening loss, and lower yields of marketable beans.

Shattering losses may occur before pulling or windrowing, if the crop has become over-mature before harvesting operations are started, or may be a result of the pulling and windrowing operations. Harvest as soon as possible after the crop is ready, and handle the vines carefully.

Windrow pickup losses are a result of beans shattering from the pods as the windrow is being picked up. Careful handling, and harvesting when the pods are tough will help keep this loss to a minimum.

Cylinder losses represent those beans which are carried over the straw rack and deposited on the ground behind the combine, without having been threshed from the pods. With field beans, these losses are usually quite low, and split beans or cracked seedcoats from over-threshing is usually a more serious loss.

Straw rack losses represent those beans completely threshed out of the pods, but carried over the straw rack with the straw. Straw rack losses are usually quite low, but may become excessive if the rack speed is too low, or if the straw racks are overloaded.

Cleaning shoe losses represent those beans lost over the chaffer extension and adjustable sieve. Proper adjustment of the chaffer extension and cleaning sieve, and proper control of the amount and direction of the air blast, is necessary to keep cleaning shoe losses low.

TABLE 9. BEAN DISEASES, SYMPTOMS, AND CONTROL.

BACTERIAL BLIGHTS — Bacterium

(Common) *Xanthomonas phaseoli*
(Fuscous) *Xanthomonas phaseoli* var. *fuscans*
(Halo) *Pseudomonas phaseolicola*

SYMPTOMS	METHOD OF TRANSMISSION	CONTROL MEASURES
Small water-soaked spots occur on the stems, leaves, and pods. These gradually enlarge and become reddish. Later, dead areas surrounded by yellowish-brown areas, appear on the leaves. The leaves become riddled and shredded. Infected seed may be shriveled. In late infections, the seed appears varnished. On white seeded varieties the yellow discolorations for both common and fuscous blight can be seen through the seed-coat. These two organisms produce a yellow bacterial ooze on the lesions which appear on the stem, pod, and leaf. This is in contrast to the Halo blight organism which produces a white bacterial ooze. Halo blight can readily be recognized by a light green halo surrounding the point of infection.	Rains, heavy dews, and humid weather favor the spread and development of the bacterial pathogens. Warm weather favors the development of common and fuscous blight; cool weather favors Halo blight. Bacteria enter the bean plant through the stomata or breathing pores of the leaves, stems, and pods. Bacterial ooze from the infected plant will adhere to clothing, farm implements, animals and insects, and is thus spread by these carriers. Bacteria may remain alive for many years in seed and may over-winter for two years on dead plant material in the soil.	1. Use disease-free seed (certified seed is recommended); 2. Practice at least a 3 or 4 year crop rotation; 3. Keep the fields clean by plowing under bean refuse; 4. Avoid working in bean fields while they are wet.

ANTHRACNOSE — Fungus

Colletotrichum lindemuthianum

SYMPTOMS	METHOD OF TRANSMISSION	CONTROL MEASURES
Dark-brown to reddish sunken cankers appear on the pods, stems, and on veins of leaves infected by the fungus. Lesions on the pods are more or less circular and under moist conditions, flesh-colored masses of spores appear in the center of the lesions. Infected seed will have dark and sometimes raised lesions that extend into the seed.	The fungus that causes bean anthracnose is seed borne and capable of living in the soil for two years. It is spread by rain, insects, farm implements, and man. The fungus thrives especially well in moderately cool, humid, and rainy weather. It attacks all parts of the plant and at almost any stage of growth. The fungus establishes itself in the seed through deep pod infections.	1. Plant disease-resistant varieties; 2. Use disease-free seed, (certified seed is recommended); 3. Practice at least a 3 or 4 year crop rotation; 4. Keep the fields clean by plowing under bean refuse; 5. Avoid working in bean fields while they are wet.

MOSAIC — (Common) Phaseolus Virus 1 and variant
(Yellow) Phaseolus virus 2

SYMPTOMS	METHOD OF TRANSMISSION	CONTROL MEASURES
The common and yellow bean mosaic viruses cause stunting of the plant and the mottling and malformation of the leaves. Leaves become irregular in shape, with light green to yellow areas interspersed between dark green areas which sometimes are puckered. Plants of some varieties set very few pods. It is often difficult to distinguish between bean common and bean yellow mosaic virus infections. Ordinarily there is more contact between the light green and dark green areas when the bean is infected with bean yellow mosaic virus.	Common mosaic is seed transmitted; bean yellow mosaic is not. In the latter case the virus over-winters in leguminous plants. Bean mosaic is transmitted from plant to plant by plant lice or aphids.	1. Plant resistant varieties; 2. Use disease-free seed (certified seed).

SCLEROTINIA WILT — Fungus

(White mold) *Sclerotinia sclerotiorum*

SYMPTOMS

Sclerotinia wilt appears first as small water-soaked spots on stems, leaves, and pods. These spots enlarge rapidly under cool, moist conditions, and in a few days white masses of mold appear on the infected areas. The white mold soon turns gray or brown, and small black bodies appear on the lesions or in the pods and stems. The fungus may girdle the main stem or its branches, causing the plant to wilt and die. Infected pods become soft and mushy. No pods may be set if the plant is attacked early.

METHOD OF TRANSMISSION

The small black bodies, or sclerotia, fall to the ground at harvest time where they can lie dormant for 10 to 20 years When conditions are favorable for fungus growth, strands of white mold grow out of the sclerotia and infect the plants directly or they may produce tiny mushrooms upon which spores are produced. Spores are ejected into the air and carried by air currents to the leaves and stems of the bean plants. Sclerotia appear to be the principal source of field infection. The disease may also be transmitted through infected seed. Under present methods of combining, the disease tends to spread since the sclerotia are scattered back over the field during combining.

CONTROL MEASURES

Follow as long a crop rotation as possible. It is wise to use small grains, corn, and hay in the rotations since these crops are not susceptible to the disease. Bush-type navy beans are damaged less by white mold than the vine-type varieties.

ROOT ROTS — Fungus

(Fusarium root rot) *Fusarium solani* f. *phaseoli*

(Damping-off and seed decay) *Pythium aphanidermatum*

P. debaryanum

Rhizoctonia solani

SYMPTOMS

Numerous fungi attack the below-ground portions of the plant, forming various types of lesions on the stem and roots. The weakened plants turn yellow, become stunted, and may die. Fusarium root rot causes a reddish discoloration of the roots and stem and often the taproot is rotted off. New secondary roots are then produced above the infected part of the plant. During the dry season, when there is insufficient moisture for the new roots to establish themselves, the plants may die. Infection by other root rot fungi generally occur during the early stages of plant growth. This type of root rot is called damping-off and seed decay. These fungi ordinarily attack beans growing in cold wet soils.

METHOD OF TRANSMISSION

Root rot organisms are common soil inhabiting fungi. Some of the fungi attack other crops and are able to survive for long periods in soils where no cultivated crop is grown. In some years they may cause extensive damage to the bean crop.

CONTROL MEASURES

Fusarium root rot is best controlled by following a crop rotation. The least root rot generally occurs if corn precedes beans in the rotation. The use of sugarbeets or wheat and oats preceding beans in the rotation is also recommended for reduced amount of root rot. Damping-off and seed decay is controlled by seed treatment. It is recommended that a combination insecticide and fungicide be used in this case. See the section on seed treatment.

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