Navy Bean Production: Methods for Improving Yield
Michigan State University
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NAVY BEAN PRODUCTION: Methods for Improving Yield

BY A. L. ANDERSEN, L. S. ROBERTSON, J. R. BLACK, M. H. ERDMANN, and R. F. RUPPEL[1]

Summary

This report summarizes recommendations based upon many years of research and upon hundreds of field observations made by the specialists working with Navy beans in Michigan. The data collected in 1974 are compared with specific recommendations made by the Cooperative Extension Service. Assuming that the recommendation is valid, it then becomes possible to determine where improvements could be made in production methods. Your county agricultural extension agent can help you with your production problems.

The major problems in production efficiency in 1974 included soil fertility evaluations, poor soil structure, use of non-certified seed and diseases.

Eighty-two percent of the farmers did not soil test and, therefore, were not in a good position to use fertilizer in agreement with needs. One farmer in five grew beans for the third year in a row, thus taking unnecessary risks with diseases and soil structure problems.

Evidence of field operations on wet soils was common. Two-thirds of the fields surveyed had visible evidence of poor soil structure.

Fifty one percent of the cooperators used other than certified seed. These producers had no guarnatee that they were using the best available seed. Twenty eight percent used their own seed.

The major diseases in 1974 included Fusarium root rot, white mold and bacterial blight. Bacterial blight was observed in 75 percent of the fields. More than 50 percent of the fields had Fusarium root rot ratings in excess of 2.0, which is the threshold level where yields are likely to be reduced.

Thus, there is considerable evidence that there are great opportunities for increasing Navy bean yields in Michigan.

YIELDS OF DRY BEANS IN MICHIGAN trended upward from 1950 through 1964, but current yields are significantly lower (Figure 1). Explanations of the yield plateau are not clear; during this time expanded research and extension programs were in effect. To gain a better understanding of the situation, an inventory program was developed to analyze most phases of bean production. The goal of this project was to locate bottlenecks so that educational and research programs could be designed to increase production efficiency and to reduce risks by defining management practices essential for disease, insect, and weed control and for general plant health.

Inventory Methods

Navy beans in 100 individual fields in eight major producing counties were studied in 1974 in detail by a team representing the U.S. Department of Agriculture, the Michigan Department of Agriculture, the Michigan Department of Public Health and Michigan State University (Appendix A). Producers were selected by agricultural extension agents. Specific locations within a study field were determined by a specialist team of agronomists and plant pathologists. Environmental conditions and general crop health were monitored in each field. Agronomists visited each field early in the growing season, well before blossom time. Entomologists and pathologists working with the extension staff kept each field under observation during the entire season.

Most farmer cooperators responded to a questionnaire which considered several management inputs including crop rotation, fertilizer, tillage practices, variety, source of seed and seed treatment. Harvests at a predetermined location within each field were made by hand in one-half of the fields. In addition,

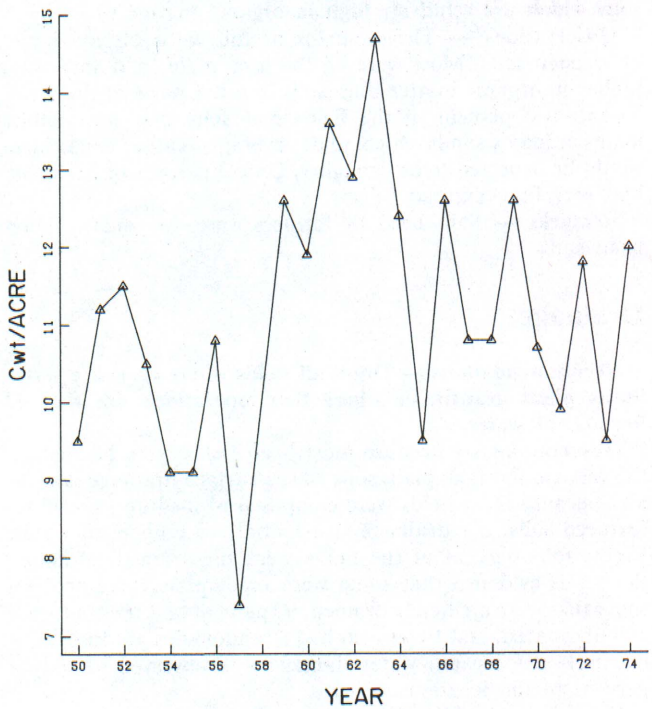


Fig. 1 — Yield/Acre of Drybeans in Michigan 1950-1974.

[1] *Botany and Plant Pathology, Crop and Soil Sciences, Agricultural Economics, Crop and Soil Sciences, and Entomology, respectively.*

most farmers supplied yield information for entire fields. Data were transferred to computer cards and analyzed, using standard statistical methods. This paper summarizes management systems reported by farmers and the impacts of systems on plant health and performance.

Results and Discussion

Navy Bean Yields

Field yields as reported by farmer cooperators ranged from 480 to 2,500 pounds per acre (Table 1). This wide range is typical of what occurs every year. The average yield, 1,568 pounds, is higher than the 1,200-pound state average yield. While there may be some differences, there is little doubt that the practices observed on the 100 farms are representative of most bean producers in Michigan.

With few exceptions, no single reason easily explained either the highest or lowest yields. Invariably, the levels represented a package of management inputs as modified by prevailing weather. The following discussion explains in part why such a wide range in yield was obtained.

Table 1. Range and average yields of Navy beans.

County	Yield pounds per acre	
	Range	Average
Arenac	900-1800	1380
Bay	1020-2040	1426
Gratiot	1400-2500	1817
Huron	480-2100	1509
Midland	1140-2400	1770
Saginaw	1260-2280	1821
Sanilac	802-1620	1176
Tuscola	1100-2280	1684

Kinds of Soils

Recommendations —Grow beans on deep, medium-textured soils which are relatively high in organic matter.

Observations — Three-fourths of the fields observed had good bean soils. Most were on the lake plain, and therefore, higher in organic matter than soils in other parts of the state. Twenty-two percent of the fields had soils that were sandy loams or loamy sands which, under average weather conditions, would be expected to be droughty. Only 3 percent of the fields had very fine textured soils.

Remarks — Soils used by farmers were, in general, good bean soils.

Drainage

Recommendations — Drain all fields where excessive water limits plant growth, or where field operations are delayed because of water.

Observations — Because most bean fields were located on the relative flat lake plain soils where surface drainage is slow, and because most fields were composed of medium- and fine-textured soils, tile drainage is essential for high bean yields. Eighty-four percent of the fields were tile-drained, although there was evidence that some were inadequately drained. Of those that were artifically drained, 90 percent had tile that were equally spaced, and 10 percent had a random design. In 1974, a relatively dry season, water damage was observed at only 4 percent of the locations.

Remarks — While tile drainage helps, tile becomes less effective when the soil is packed by tractors and other implements. Yields undoubtedly could be increased through the use of more tile and by being more careful about soil moisture levels during field operations. Yields on tiled soils were 300 pounds per acre higher than on non-tiled soils. This difference would be even greater in wet years.

Soil Testing

Recommendations — Test soils at least once every three years.

Observations — Of those farmers who reported, 82 percent did NOT test their soils. This means that in most instances the producers were guessing how much and what kind of fertilizer to use.

Remarks — Because of the generally high soil test levels in the bean producing counties, soil testing is now used primarily as a basis for determining the amount of fertilizer needed to maintain a high soil fertility. In general, producers use excessively high fertilizer rates. The cost of the extra fertilizer used was much greater than the cost of soil sampling and testing. Through soil sampling and testing, many bean producers could reduce costs of production without sacrificing yields.

Fertilizers

Recommendations — Base fertilizer use upon soil tests. Use most of the fertilizer as a banded, planting-time treatment. Locate the band one inch to the side and two inches below the seed.

Observations — Most cooperators used banded, planting-time fertilizers. In many instances, the band was located several inches to the side of the seed, thus delaying utilization of fertilizer elements. Of those cooperators that reported, 24 percent used more than 40 pounds of nitrogen (N). Another 25 percent used more than 68 pounds of phosphorus and another 25 percent used more than 60 pounds per acre of potash. On the average, this is more than is economically necessary. No symptoms of phosphorus or potassium deficiencies were observed. Nitrogen deficiencies were present in several fields, even in some fields where plants were well nodulated. Manganese-deficiency symptoms were observed at several locations where manganese use was reported. Zinc deficiency symptoms were observed at only one location.

Remarks — The very high soil fertility levels of the Saginaw Bay and Thumb areas greatly reduced the potential for nutrient deficiencies. Fertilizer costs on most farms could have been reduced if cooperators had used fertilizers primarily to maintain soil fertility levels. On several farms, fertilizer would have been used more effectively if it had been banded closer to the seed. The manganese deficiency symptoms observed suggest that either the manganese in the fertilizer was not in an easily available form or that the fertilizer containing the manganese had been broadcast. This situation needs further investigation.

Crop Rotation

Recommendations — Grow beans in long rotations to give good soil structure and as an aid in controlling insects, weeds and diseases. Grow crops that minimize the number of times that the soil needs to be tilled. As an aid to soil structure stabilization, include crops in the rotation that supply large volumes of organic matter.

Observations — Many rotations tend tc produce poor soil conditions for root and shoot development (Table 2). These conditions provide favorable environments for disease development. Almost one-fourth of the fields had beans the

Table 2. Previous crops.

Previous crop	Percent of Fields 1972	1973	Average
Alfalfa	2	2	2
Beans	37	23	30
Corn	12	34	23
Small grains	13	21	17
Soybeans	1	4	3
Sugarbeets	21	9	15
Other	13	6	10

previous year. Thirty seven percent of the fields had beans two years ago. Only two fields had alfalfa in each of the two years, and only 12 percent produced corn in 1972 and 34 percent in 1973. The farms with an excellent soil structure had yields 280 pounds above the remaining soils.

Remarks — The cropping systems used by many bean farmers require plowing and numerous cultivations every year. This reduces the stability of the soil structure because cultivation destroys organic matter. With beans grown so frequently, the opportunity is increased, for root rot and baceterial blight to develop. This was especially evident in 1974.

Green Manures and Livestock Manures

Recommendations — Use green manure and cover crops wherever possible to add organic matter to the soil and to protect the soil from erosion. Where available, plow down livestock manure at medium rates, 5 to 10 tons per acre, immediately after application.

Observations — Of those who reported, 82 percent did not use green manure crops of any kind. The green manure crops that were used included clover (8%), alfalfa (5%), and other crops (5%). Less than 2 percent of the cooperators used any livestock manure, primarily because most farms represented cash crop enterprises.

Remarks — Green manure and cover crops represent a very real way not only of conserving the soil but of increasing acre yields. While such inputs cost money and time, under most conditions they are economically feasible. Many farmers, because they plow in the fall, do not seriously consider this input. Because beans are planted so late in the season, fall plowing is not necessarily essential or desirable on the medium and coarse textured soils.

Tillage

Recommendations — Till the soil only when dry and only to a depth that includes a compacted zone or to control insects, diseases and weeds. Do not repack the soil with secondary tillage tools, weed sprayers and fertilizer spreaders after plowing.

Observations — While most farmers used some form of primary tillage, 5 percent did not plow. Thirty-four percent plowed in the spring and 61 percent in the fall. The disc was used on 56 percent of the farms. Thirty-two percent used it once, 9 percent twice and 3 percent three or more times. Where the disc was not used, the field cultivator represented the most important secondary tillage tool. Sixty two percent of those who used a field cultivator used it at least twice. One cooperator used it 6 times.

Remarks — Many bean farmers could have easily reduced the amount of tillage in 1974. The treatments reported here did not include tillage for incorporated herbicides. Of even more importance is the fact that some could have been more careful about soil moisture levels at tillage time. A great deal of compaction was observed while evaluating root structures. Less tillage, especially when subsoil moisture levels are high, represents another way that bean production costs could be reduced without sacrificing performance.

Cultivation

Recommendations — Cultivate only to destroy a crust or weeds.

Observations — Of those farmers who reported, 6 percent cultivated once, 71 percent twice, and 22 percent three or more times. A great deal of root pruning by cultivators, especially on compacted soils, was observed.

Remarks — Most farmers had a very good weed control. Some soils tended to crust easily. Cultivation improved conditions, however, so that after replanting, crusts were not a serious problem in 1974. Some soils were cultivated when the soil was too wet. Also, some fields were cultivated so deeply that root pruning occurred. Apparently some farmers feel that beans are harvested more easily when they are well ridged. This may be true, but too much root pruning occurred when large volumes of soil were moved into the row.

Soil Structure

Recommendations — Create a seed and root bed that is loose and mellow and has a stable structure which is resistant to deterioration by wind and water.

Observations — Two-thirds of all the fields observed showed evidence of poor soil structure. This was more than expected.

Remarks — The effects of the poor soil structure were not as devastating in 1974 as they could have been under different climatic situations. With roots restricted to the surface soil they were not, on the average, seriously affected in 1974 by moisture or nutrient deficiency. On most farms, rains fell soon after the soil became dry.

Quality Seed

Recommendations — Plant high-quality, disease-free seed.

Observations — Forty-nine percent of the farmers planted certified seed. Approximately 28 percent used their own seed. The remainder planted noncertified seed purchased from elevators or local seedsmen.

Remarks — The selection of high-quality, disease-free seed is one of the first steps in producing high yields. Bacterial blight is of greatest concern because bacteria can live for many years in seed and thus serve as a primary source for field infection when used for seed. Rigid standards for seed certification, including field and laboratory inspection, seed germination tests, and the requirement that all certified seed pass the Michigan Department of Agriculture bacterial blight test, are the basis for superior seed.

Time of Planting

Recommendations — For rapid germination and to avoid damage from Fusarium root rot, damping-off and seed decay, plant beans in a warm, moist soil.

Observations — Only 8 percent of the fields planted before June 5 escaped injury from root rot while 50 percent of the fields had very severe root rot. In contrast, 73 percent of the fields planted after June 9 escaped injury from root rot, and only 12 percent had severe root rot. There was a higher frquency of the fields planted June 5 to June 9 with moderate to severe root rot than those that escaped (Figure 2).

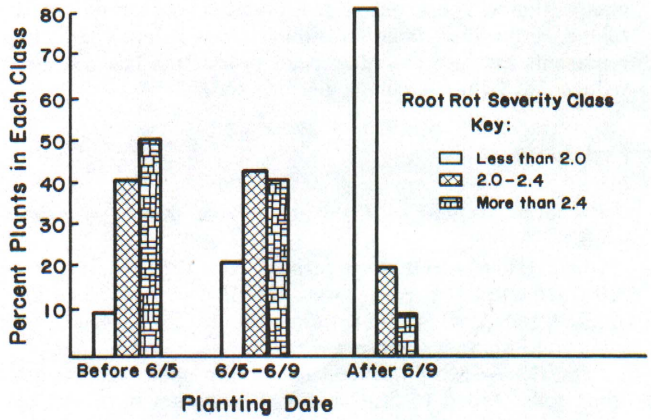


Figure 2. Incidence of Fusarium root rot as related to planting date.

Remarks — There was a striking correlation between root rot severity and planting date. This probably related directly to the soil moisture and temperature stresses at the time of, and immediately after, planting. The delayed planting in several counties was a result of excessive rain during late May and early June. Many early-planted fields had to be replanted because of Fusarium root rot.

Herbicides

Recommendations — Herbicides, alone or in combination with other herbicides are recommended for Navy beans in Michigan.

Observations — Herbicides were used on 97 percent of the fields. Eptam was used by 82 percent of the growers, some alone but more often in combination with other herbicides. Treflan was the No. 2 herbicide, with 51 percent of the growers using it, frequently in combination with other herbicides. Only three growers used Treflan alone. Fourteen growers used Amiben, either alone or in combination with other herbicides.

Remarks — Herbicide usage was generally in line with recommendations. Eptam is the most consistent, broad-spectrum herbicide available. In combination with other herbicides, it has two advantages: (1) the rate of Eptam may be reduced and decrease the possibility of stress associated with Fusarium root rot, and (2) a broader spectrum of weed control and/or longer-term weed control may be obtained when Eptam is used in combination with other herbicides. Treflan used alone has limitations in controlling some broadleaved weeds, but it provides good weed control later in the season. In combination with Eptam, it reduces stresses associated with higher rates of Eptam, Amiben, Premerge and Sinox PE, and helps control nightshade when applied pre-emergence after a pre-plant treatment of Eptam or Treflan. When Amiben, Premerge or Sinox PE are used alone, their effectiveness depends upon adequate rainfall after treatment. For detailed instructions on herbicides, refer to MSU Extension Bulletin E-434 on "Weed Control in Field Crops."

Ribbons of compacted soil caused by disks on a cultivator. Obviously the subsurface layer of soil was much too wet at cultivation time.

Diseases

BACTERIAL BLIGHT

Recommendations — All management practices described in MSU Extension Bulletin 680, "Grow Blight-Free Field Beans," must be followed in order to eliminate and/or prevent bacterial blight.

Observations — Bacterial blight was observed in 75 fields. In most fields the grower neglected one or more of the management practices described in Bulletin 680.

Remarks — Every grower should be more informed about blight control. Extension Bulletin 680 is easily available in each county extension office. Planting MDA-tested, blight-free seed is the most significant single step a grower can take to reduce bean bacterial blight problems. Other methods are outlined as follows:

Seed Treatment

Recommendations — Treat seed with a combination of chemicals which include a bactericide (streptomycin), a fungicide (captan or thiram) and an insecticide (diazinon or dieldrin). If seed cannot be slurry treated, use the planter box method.

Observations — Sixty farmers planted treated seed. Fourteen used a slurry and 46 treated in the drill box. However, only one-half of the farmers included streptomycin. Captan was the principal fungicide, and diazinon and dieldrin were the most common insecticides.

Remarks — If blight was present in fields that were planted with seed not treated with streptomycin, the bacteria could have been present on the surface of the seed, or internally if the MDA test had not been used. Poor, weak or uneven stands resulted where seeds were not protected from soil-borne pathogens and corn maggot injury.

Safety Precautions

Recommendations — Use a dust mask or respirator and wear impermeable gloves when adding and stirring planter box seed treatment chemicals.

Observations — Some of the growers who used the planter box method reported adverse health effects.

Remarks — Safety is the most important factor in handling and using farm chemicals. No problems were reported by growers who observed even minimal precautions, such as mixing with a stick, wearing protective masks and gloves, and staying upwind while adding and mixing the seed protectant with beans.

Cropping Sequence

Recommendations — Allow at least 2 years between bean crops to reduce the possibility of a bacteria carryover from previous bean crops.

Observations — As mentioned under crop rotation, beans were planted after beans in 23 percent of the fields in 1973, and 37 percent of the fields were planted to beans in 1972. For 20 percent of the growers, this was the third year in succession their fields had beans.

Remarks — If blight had been present in these fields in 1972 or 1973, it could have been a prime source of contamination in 1974.

Field Contamination

Recommendations — Never work in bean fields while the plants are wet.

Fusarium root rot, caused by a fungus that attacks the underground portions of the plant, is present throughout the bean growing area. Using a rating of 0 to 5, disease severity was determined on approximately 100 plants from each of the 100 fields.

LEFT: If beans are planted after corn, Fusarium root rot should be at a minimum. When beans followed 10 years of corn there was absolutely no evidence of root rot on the bean plants.

RIGHT: Many uneven stands can be attributed to Fusarium root rot.

Observations — On several occasions, farmers were observed either weeding or cultivating while plants were wet.

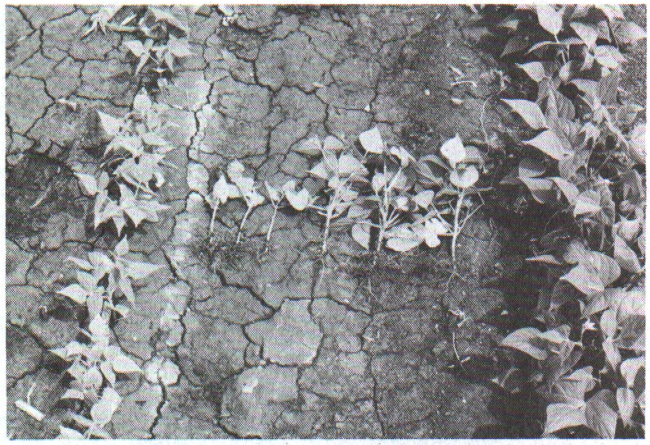
Remarks — Bacteria are produced in a gelatinous matrix which adheres to tools, machinery and clothing when moisture is present. Thus, bacteria are easily distributed from plant to plant when the beans are wet.

FUSARIUM ROOT ROT

Recommendations — Create a soil environment that permits rapid growth.

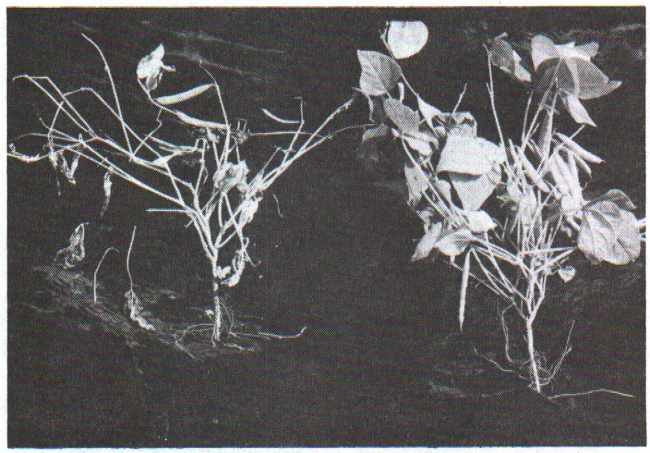
Observations — Twenty-four percent of the fields under observation had a root rot rating of 2.5 or higher. Research has shown that such levels may result in a great yield reduction. An additional 27 percent had root rot ratings from 2.0 to 2.4. The degree of root rot in this category may affect yields but to a less extent. Finally, 48 percent of the fields had no root rot problems. The readings in these fields varied from 0 through 1.9. Huron and Saginaw Counties had the most severe root rot problems with 40 and 42 percent, respectively, in the moderate to severe root rot category (above 2.5).

Remarks — When lower roots become non-functional as a result of Frusarium root rot, beans can develop a secondary root system. Ordinarily the secondary root system develops laterally with most of the roots near the surface, especially on compacted soils. If such roots are not disturbed, and if sufficient moisture is available throughout the growing season, the effects of Fusarium root rot are minimal. Such was the case in 1974.



Bad soil structure was caused by several practices—many involving heavy tractors. In several fields the location of tractor-compacted soil was easily seen. Poor and good growth were observed side by side. Note strong soil crust.

Shallow root systems showed in several ways. When roots were restricted to the surface two or three inches, they became very fiberous.



White mold, a fungus disease, caused much damage to beans in 1974. Early infection during the flowering period may mean complete loss of all beans on a plant. All plants in a field may become infected under optimum conditions for development of the disease.

Herbicide Usage

Recommendations — Herbicides are strongly recommended for efficient Navy bean production [see section on herbicides].

Observations — Although certain chemicals affect root rot development, there was no evidence to relate root rot severity and herbicide usage to yield reduction in the fields examined, even when Eptam was used alone.

Remarks — Research has demonstrated that yields can be reduced as much as one-half by Fusarium root rot when Eptam is used alone. Generally this occurs when beans are subjected to other stresses.

Cropping Sequence

Recommendations — Allow at least 3 years between bean crops with beans following corn, alfalfa or wheat seeded with green manure crop.

Observations — Bean fields with no Fusarium root rot were observed. In all cases, corn had been grown for several years previous to beans. Root rot was most severe when beans followed beans.

Remarks — Root rot infection can be reduced by planting beans after corn provided that atrazine is not used the year immediately before beans.

WHITE MOLD DISEASE

Recommendations — Allow at least 3 years between bean crops, and plow under all infected debris. If necessary, apply benomyl, a systemic fungicide, during blossoming. Follow recommendations given in MSU Department of Botany and Plant Pathology Plant Disease Report No. 30, dated August 9, 1974.

Observations — White mold was observed in 63 fields. Nine of the 63 fields had 10-25 percent infection, and 15 had from 5-10 percent. The disease was observed in only one field which was in full bloom. In 6 fields the disease was first observed where plants were in the small pod stage, in 12 fields in early pod fill stage, and in 5 fields the plants had reached the full pod stage before the disease was observed.

Remarks — Conditions were especially favorable for white mold development during the second week in August. At that time, plants were at an optimal stage for infection. Apparently the fungus was fruiting and discharging spores, and the weather conditions were ideal for infection. Plant pathologists working with the county extension agents will again attempt to alert growers when conditions are favorable for white mold infection and development. Refer to the control methods given in plant disease Report No. 30, mentioned above.

BEAN RUST

Recommendations — Plow under all bean refuse, preferably in the fall if other conditions permit, to reduce the rust inoculum potential from the previous season. If 2-10 rust spots are observed per leaf during early bloom, full bloom and small pod stages, or if there are 40 or more spots per leaf during small pod and early pod fill stages, apply a fungicide as recommended in MSU Department of Botany and Plant Pathology Plant Disease Report No. 29, dated August 9, 1974.

Observations — Bean rust was present in 53 of the 100 fields. Rust was observed in one field before bloom and in 13 fields in the small pod stage. The remainder of the fields were in the early pod fill or within 3 weeks of maturity before rust was observed. The disease was severe enough in only two fields to cause major defoliation.

Remarks — Michigan's first rust epidemic in Navy beans occurred in 1973. Even though infection was observed in several fields in 1974, a serious problem did not develop. The exact conditions for development of this disease on Navy beans have yet to be determined.

BRONZING

Recommendations — Because bronzing (air pollution injury) is common and damage is greatest when the beans are already under stress, the producer should follow all of the cultural practices recommended for optimum bean production. If beans are not under stress, air pollution problems are likely to be reduced.

Observations — Approximately 50 fields showed bronzing. Twelve had 5-10 percent of the leaves affected; one had 10-25 percent, and 2 had 25-50 percent of the leaves damaged.

Remarks — Bronzing was not a serious problem in 1974. Although there is little the farmer can do to reduce air pollution, he can reduce the damage by growing beans so that little or no stress is present.

Insects

Recommendations — Learn to identify all bean insects and the methods of control.

Observations — Green clover worms were present early in the season, but plant injury was minor.

Mexican bean beetles were observed in 9 fields but only 3 had significant damage.

Aphids appeared late in the season when plants were in the full bloom to full pod stages. Damage was minimal.

Potato leafhoppers were easily seen by mid-August in 16 percent of the fields. Damage was minimal.

Tarnished plant bugs were observed in 12 percent of the fields that had reached the early bloom to full pod stage of development in the period August 12-16. No damage to plants was observed.

Remarks — Although insects were not a serious problem in 1974, growers should be alert to their presence and seek advice from extension agents on the need for chemical control. Refer to MSU Extension Bulletin 499 for detailed description of insects, and their control.

Cooperators in this Survey

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Other MSU Departments — Dale E. Linvill, Agricultural Engineering, and Clifford L. Bedford, Food Science and Human Nutrition.

Michigan Department of Agriculture — Plant Industry Division, Region III Field Staff: Eugene Wenzloff, Donald Stout, Charles Palmer, Kenneth Rauscher, Norman Remington, David Dunn.

Michigan Department of Public Health — Bureau of Laboratories, Pesticides Section: Arthur Bloomer.

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COOPERATIVE EXTENSION SERVICE

MICHIGAN STATE UNIVERSITY · EAST LANSING · MICHIGAN 48823

AND U.S. DEPARTMENT OF AGRICULTURE COOPERATING

Department of Botany and
Plant Pathology

May 30, 1975

This report was prepared especially for bean growers in Michigan by extension specialists at Michigan State University. We are especially appreciative to the 100 Michigan farmers that cooperated in the project by providing detailed information on their cultural practices and by allowing us to enter and observe their bean fields throughout the growing season. We also thank the Michigan Bean Commission and the Michigan Bean Shippers Association for their part in supporting this program. Furthermore, this project would not have been a success without the help received from the coopera-tors listed in the fact sheet.

Sincerely yours,

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