UNIVERSITY OF IDAHO
AGRICULTURAL EXPERIMENT STATION
DEPARTMENT OF PLANT PATHOLOGY

BEAN IMPROVEMENT AND BEAN DISEASES IN IDAHO

BY
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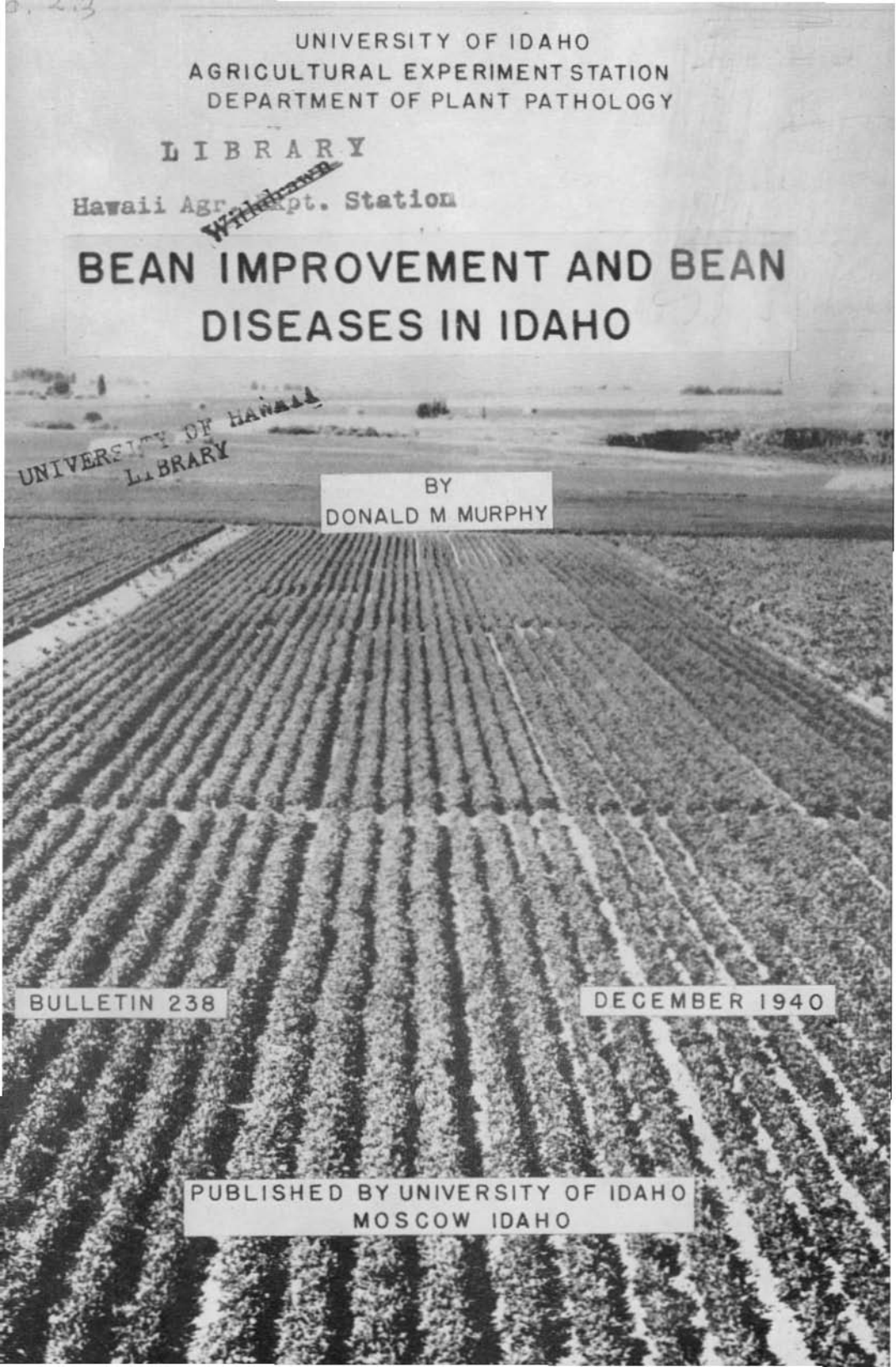

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Foreword

THE Bean Improvement Program was initiated in 1925 by the Plant Pathology Department of the Idaho Agricultural Experiment Station and was made possible by federal Purnell research funds. Growers in south-central Idaho had for years experienced serious losses from mosaic and other bean diseases, and the project was developed after many requests from bean growers for assistance in combating these diseases.

In 1936 the project was supplemented with funds obtained from a special grant by the Idaho Legislature known as the Beet Leafhopper Fund. This work has been continued during the last two bienniums by additional grants of the Legislature. At the present time the program is conducted under a cooperative agreement between the State of Idaho, the University of Idaho Agricultural Experiment Station, the Bureau of Entomology and Plant Quarantine, and the Bureau of Plant Industry of the United States Department of Agriculture. These investigations deal with the control of the beet leafhopper and the breeding of beans resistant to curly top.

Since the Bean Improvement Program was started, a number of Great Northern bean selections resistant to the virus of common bean-mosaic have been developed and introduced. These Great Northern bean selections are grown almost exclusively by growers in the Great Northern bean growing sections in Idaho. Great Northern and Red Mexican hybrid selections resistant to the viruses of curly top and common bean-mosaic have also been introduced and are now in commercial production in Idaho.

Bean Improvement and Bean Diseases in Idaho

By

DONALD M. MURPHY*

THE bean crop is one of the important cash crops in Idaho. This State ranks third in the total bean production in the United States and first in the production of two commercial classes, Great Northern and Red Mexican. During 1933-1937, Idaho produced 10.8 per cent *(14)*** of the total United States production; and this amount included on a 5-year average (1933-1937) 57.9 per cent of the Great Northern class and 90.8 per cent of the Red Mexican class production. In 1939, Idaho produced 1,551,000 one-hundred pound bags of beans or 11.1 per cent of the total bean production. Out of a total Great Northern bean production in the United States of 1,544,000 bags, Idaho produced 928,000 bags or over 60 per cent in 1939. Of a total United States production of 309,000 bags of Small Red beans in 1939, Idaho produced 266,000 bags or 86 per cent of the total. Idaho has the highest yield per acre of any state with an average yield of 1,304 pounds (1933-1937), while for the United States as a whole the yield was 782 pounds per acre. In 1939, the yield per acre was 1,410 pounds while the yield for the country as a whole was 898 pounds. A 5-year average of 112,000 acres annually were planted to beans in Idaho of which 109,000 were harvested.

Three commercial classes of field beans are well adapted to the soil and climatic conditions of Idaho. Great Northern and Red Mexican varieties thrive in the irrigated districts of southern Idaho while the Small White does well in the areas of sufficient rainfall of northern Idaho. The production of seed of many garden bean varieties is also very important in southern Idaho. The growing season is of sufficient length in the production areas to insure the maturity and harvesting of the crop.

Bean diseases have often made severe inroads in the Idaho bean crop. Losses may occur through a reduction in the yield or through damage to the quality of the crop in certain seasons. In order to reduce these losses to the Idaho bean growers, a bean improvement program was initiated; and, as a result, bean varieties resistant to the cause of some of our important bean diseases have been introduced to the growers and are now in commercial production.

This bulletin describes new bean varieties which have been released to Idaho growers and more recent selections which are still being tested. The results of field trials of various bean selections are presented. As the improvement program deals largely with disease control, a description of the symptoms of the important bean diseases found in Idaho have also been included.

Other Work in Bean Improvement

The common bean was first thought to be of Asiatic origin, but it is now believed to be a native of tropical America. A large number of related species of beans have been found in Mexico and Brazil. The bean

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**The figures in parenthesis refer to the "Literature Cited" at the back of the bulletin.

Figure 1.—General view of the 1939 Buhl Experiment Plot showing Great Northern plots in foreground.

plant, although somewhat difficult to cross, lends itself to hybridization; and many private and public agencies have introduced new and improved varieties through hybridization and selection.

The 1937 Agricultural Yearbook *(17)* gives a brief summary of the work done by public and private agencies on the introduction of new varieties of field and garden beans and work on the genetic nature of the bean plant. In 1937 a new variety of white navy bean called Michelite *(5)* was released by the Michigan State Agricultural Experiment Station. Workers at the New Mexico Agricultural Experiment Station *(16)* tested several strains of Pinto beans for use in New Mexico. A list of bean varieties released to the Idaho bean growers by the Plant Pathology Department of the Idaho Agricultural Experiment Station will be found later in this Bulletin under "Results of Bean Improvement Program."

Materials and Methods

Experiment Plots

Each season several bean experiment plots were established in southern Idaho on which to conduct the field studies of the bean improvement work. The largest plot *(Figures 1 and 2)* was located 5 miles west of Buhl, at the edge of the irrigation district and in an area usually the most severely infested with beet leafhoppers. Other plots were located in important bean-growing areas near Twin Falls, Hazelton, Jerome, and Gooding.

It is fortunate that the most serious bean diseases in Idaho can be controlled by a bean breeding program. This is possible for several reasons. First, resistance to a disease producing organism seems to be a definitely inherited factor, and plants will segregate into resistant and susceptible types if crosses are made of resistant and susceptible parents. Even if the exact manner in which resistance to an organism may be inherited in

a plant is not known, this fact may not inhibit a practical breeding program. The fact that resistant types can be selected from certain crosses gives promise of combining with the resistance other factors that make the plants of commercial importance. It is also fortunate that bean varieties are available which are resistant to the different disease organisms. In one case several individual plants of a variety were found resistant and were selected out of that variety.

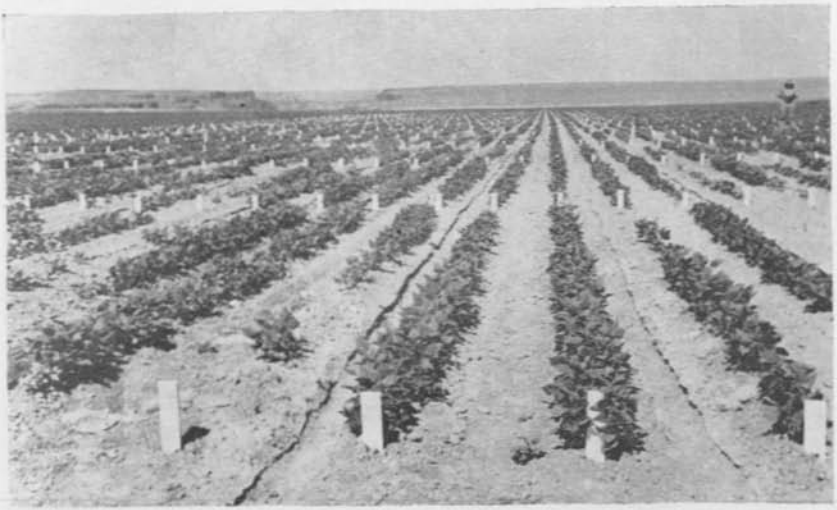

Figure 2.—General view of the 1940 Buhl Experiment Plot showing selections planted in short rows.

Varieties Studied

Most of the selections of beans tested on the experiment plots were hybrids, selected from crosses of the present important commercial varieties crossed with the most suitable of the resistant types. Parent types in the field bean class include Great Northern, Red Mexican, Pinto, and Small White. In the garden bean group varieties of both pole and bush beans were used. In each of the groups wax and green podded varieties were used in hybridization work. Some of the garden parent varieties included Refugee, Bountiful, Giant Stringless, Sure Crop Wax, Brittle Wax, Pencil Pod, Blue Lake, Kentucky Wonder Green Pod, Kentucky Wonder Wax, Asgrow Stringless Green Pod, Tender Green, and Burpee Stringless Green Pod. Most of the above garden varieties are susceptible to common bean mosaic and curly top and yet represent our most important commercial garden bean varieties at the present time. Selections from crosses that combine the desirable qualities of the commercial varieties and the disease resistance of the resistant parents were given a thorough test on the trial grounds *(Figure 3)*.

Greenhouse Work

Most of the hybridization work was conducted in the greenhouse because of the more controlled conditions. It was possible to obtain two generations of beans in the greenhouse during a single winter. One gen-

Figure 3.—Pods of a Refugee greenpod bean plant which is resistant to curly top and common bean mosaic.

eration was grown after bean harvest in the fall and one before planting time in the spring. This method permitted the more rapid development of a new cross or the increase of an especially promising selection. Special problems encountered in the bean breeding program can best be studied under greenhouse conditions.

Care of Experiment Plots

All selections on the bean experiment plots were usually planted at the same time as the farmer planted his own bean crop. This practice permitted cultivation and irrigation of the beans on the plots to be conducted in a similar manner as the commercial crop of beans. By the growing of bean selections on different experiment plots where different cultural methods were used, the selections underwent various tests which were similar to those of commercial bean plantings.

Complete records were made of all selections during the growing season. Records were made of stand, vine and pod characteristics, bean disease counts, maturity, and yields on all selections. One of the first records made in the season was the stand count. It was necessary to obtain this count in order to calculate the disease percentages found during the season. All bean seedlings in the short rows were counted and one row in four of the larger four-row plots. Usually two readings of the curly top disease were made to record the maximum percentage of this important disease. Other disease readings included the number of plants infected with common bean mosaic, yellow bean mosaic, and baldhead. The pod and vine characteristics of garden bean selections are of special importance as the pods of beans for canning must be tender, stringless, of proper length and roundness, and of a color demanded by the trade.

Pictures were taken at various times during the season of the plots, of single plants, and of diseased plants or plant parts. These records aid in the study of the symptons of the various bean diseases and in the comparison of results from one season to another.

Plant selection work was carried on throughout the season. It is obvious that only the most promising selections can be saved as only a limited number of selections can be properly tested each season. Garden bean plants were selected on the basis of their vine and pod characteristics, were marked in the field, and were harvested separately in the fall. Field bean plant selections were usually made later in the season when the seed could be examined to determine the size, shape, and color. All single plant selections were harvested separately in the fall and planted in one 25-foot row the following season. Selections may be tested several seasons in short rows before being planted in the larger plots. After a thorough testing in the larger plots, a promising selection which meets a definite need or has superior yielding qualities may be increased and released to the bean growers.

When the selections were mature, the date was recorded and the plants were pulled or cut. The beans were matured in shocks and later threshed. A special thresher of small size *(Figure 4)* was used on the plots. The machine is mounted on a trailer and is easy to clean and move. It was necessary to clean the thresher completely before each new selection was threshed.

The beans were brought to the storage shed after threshing where they were weighed and cleaned. The selections grown on the plots for a yield test were weighed before and after cleaning. All beans saved for seed

Figure 4.—Cleaning bean thresher used on the bean experiment plots. The engine, tool-box, and separator are mounted on a trailer.

for the trial grounds were hand-picked to remove imperfect seed or any possible varietal mixtures.

Complete records of all crosses are always available. A new cross is recorded on a card file when the cross is made and each season a record of selections from this particular cross is recorded on that card. Since it requires many seasons of selection and testing to develop a new variety, a record of this kind is necessary and useful.

Results of Bean Improvement Program

The Plant Pathology Department of the Idaho Agricultural Experiment Station initiated the bean improvement work in Idaho and, since 1925, has conducted a continuous program of development of varieties of field and garden beans resistant to the causal agents of our important bean diseases. Many plant selections were made in the common Great Northern field bean by W. H. Pierce and C. W. Hungerford. This work resulted in the introduction of Great Northern U. I. 1, a variety resistant to the virus of common bean mosaic. This selection was followed by the introduction *(10)* of Great Northern U. I. 81, Great Northern U. I. 59, and Great Northern U. I. 123. Great Northern U. I. 123 is the most widely grown at the present time and together the above Great Northern selections represent almost the entire Great Northern bean crop in Idaho. The above selections are all resistant to the virus of common bean mosaic which was so destructive to the common Great Northern bean first grown in Idaho. The above Great Northern bean selections are susceptible to the virus of curly top or "bean blight", as it is sometimes called. Although these selections are much more tolerant to the curly top virus than are the more susceptible garden or "contract" bean selections, the Great Northern strains suffered severe losses in some areas during seasons when beet leafhoppers were numerous. This damage is more likely to occur near the desert breeding grounds of the beet leafhopper.

In 1934, Pierce and Walker *(13)* introduced two mosaic resistant Refugee type garden beans, Idaho Refugee and Wisconsin Refugee. Norida, a Small White type field bean, was also introduced in the bean growing sections in northern Idaho. More recent work of the bean breeding program resulted in the introduction in 1937 *(9)* of two Red Mexican varieties of beans, Red Mexican U. I. 3 and Red Mexican U. I. 34. These two varieties of beans are resistant to the viruses of both curly top and common bean mosaic and now represent the major portion of the Red Mexican crop in Idaho.

In 1939 *(8)* a new Great Northern variety, Great Northern U. I. 15, was introduced to the Idaho growers. Great Northern U. I. 15 was increased on seed farms during the 1940 season and will now be available to a larger number of growers. This Great Northern variety is resistant to the viruses of common bean mosaic and curly top and has been developed from a cross of Red Mexican and Great Northern U. I. 1. It is from this same cross that selections were made that resulted in the development of Red Mexican U. I. 3 and Red Mexican U. I. 34. Great Northern U. I. 1 contributed the resistance to the virus of common bean mosaic and Red Mexican to the virus of curly top. Resistance to both viruses were combined in the resulting selection of varieties now in commercial produc-

Table 1.—Percentage of curly top found in Great Northern bean selections.

Great Northern Selection	1936		1937		1938		1939		1940		Average
	Twin Falls	Buhl	Twin Falls	Buhl	Twin Falls	Buhl	Twin Falls	Buhl	Twin Falls	Buhl	
U. I. 15	....	0.0	....	0.0	....	0.0	....	0.0	0.0	0.0	0.0
U. 1. 123	1.0	1.4	13.0	77.4	0.0	9.0	0.0	0.5	2.3	11.7	11.6
U. I. 81	0.0	0.6	11.0	70.0	0.5	15.8	0.4	0.1	1.0	14.9	11.4
U. I. 59	0.6	2.7	13.0	90.5	0.0	25.4	0.0	1.2	3.4	21.8	15.9

tion. Great Northern U. I. 15 is resistant to both curly top and common bean mosaic viruses and can be grown in areas where curly top damage was usually very severe in the Great Northern selections mentioned above.

In Table 1 the percentage of the curly top disease found in the three commercial Great Northern varities and the new selection Great Northern U. I. 15 is presented. The readings were taken from the disease present on two series of plots since 1936. In each case curly top was much more severe on the Buhl experiment plot located at the edge of the farming area than it was on the Twin Falls plot which was located at a distance inside the farming area. Since 1936, when seed of Great Northern U. I. 15 was first available for tests, no curly top has been observed in this selection. Curly top found in the other Great Northern selections would be correlated with the number of beet leafhoppers present during that season in the area where the plots were located.

Table 2.—Percentage of curly top found in 10 Great Northern bean selections grown on the Buhl plot during 1940.

Selection	Plot I	Plot II	Plot III	Plot IV	Plot V	Plot VI	Plot VII	Plot VIII	Average
U. I. 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U. I. 123	11.9	13.7	12.4	7.8	14.6	7.6	13.9	11.9	11.7
U. I. 81	12.0	11.5	15.4	14.7	11.7	21.1	21.3	11.8	14.9
U. I. 59	25.7	17.5	27.5	20.2	15.3	20.8	26.7	20.5	21.8
C. T. 32-49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C. T. 32-99	0.0	0.0	0.0	0.6	0.0	0.7	0.0	0.0	0.2
C. T. 15-7-1-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C. T. 15-7-1-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C. T. 15-7-1-5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C. T. 15-7-3-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3.—Percentage of yellow bean mosaic found in 10 Great Northern bean selections grown on the Buhl plot during 1940.

Selection	Plot I	Plot II	Plot III	Plot IV	Plot V	Plot VI	Plot VII	Plot VIII	Average
U. I. 15	5.6	4.9	5.2	3.8	2.9	3.0	8.1	1.4	4.4
U. I. 123	3.0	0.0	1.1	0.0	0.0	0.6	0.6	1.1	0.8
U. I. 81	2.7	0.0	0.5	0.0	2.0	0.0	0.0	0.0	0.7
U. I. 59	1.4	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.5
C. T. 32-49	5.1	2.6	1.8	2.6	11.7	2.4	5.4	0.7	4.0
C. T. 32-99	6.9	6.7	3.4	2.5	1.7	3.3	2.8	5.4	4.1
C. T. 15-7-1-1	4.7	4.4	2.3	4.6	2.2	3.2	4.0	3.0	3.6
C. T. 15-7-1-4	2.9	4.7	3.1	7.4	3.2	2.6	2.3	2.7	3.6
C. T. 15-7-1-5	3.7	3.5	4.1	2.1	1.3	1.4	1.6	6.1	3.0
C. T. 15-7-3-2	1.2	5.9	2.7	9.5	0.7	1.9	4.5	1.9	3.5

Table 1 shows clearly that the seasons of 1936 and 1939 gave only slight curly top damage in all susceptible selections. Severe curly top damage did occur, however, during the season of 1937 when 70 to 90 per cent of three Great Northern bean selections were killed by curly top on the Buhl experiment plot. No curly top was found in Great Northern U. I. 15 during the 1936 season or on any trials during later seasons. The average curly top readings as presented in Table 1 indicate the Great Northern U. I. 59 had a higher percentage of curly top than did U. I. 123 or U. I. 81. This trend has been observed in these selections from tests on other experiment plots.

In Table 2 are presented the curly top disease readings as found in six new Great Northern selections still under test in the experiment plots as compared with four selections released to the bean growers. The new

Table 4.—Yield in bushels per acre of four Great Northern bean selections grown on two trial plots in southern Idaho.

Great Northern Selection	1934	1935	1936		1937		1938		1939		1940		Average
	Twin Falls	Twin Falls	Twin Falls	Buhl	Twin Falls	Buhl	Twin Falls	Buhl	Twin Falls	Buhl	Twin Falls	Buhl	
U. I. 15	....	....	....	....	....	....	....	59.9	51.4	42.5	32.7	42.2	45.7
U. I. 123	41.5	42.6	39.0	42.7	36.5	8.3	48.6	53.1	56.9	38.5	29.0	34.0	39.2
U. I. 81	41.7	38.1	46.3	28.6	37.8	11.7	51.2	51.4	51.4	40.7	31.3	36.4	38.9
U. I. 59	40.2	38.3	36.3	12.7	34.8	7.8	50.1	43.7	44.1	39.1	30.4	31.8	34.1

selections are hybrids of the Great Northern type and are resistant to the curly top and common bean mosaic viruses.

The disease of yellow bean mosaic is not seed borne and does not represent a disease of great commercial importance in Idaho at the present time. The symptoms and characteristics of the various bean diseases found in Idaho are given later in this Bulletin. All selections of Great Northern beans tested on the plots have shown some infection by yellow bean mosaic. In Table 3 the percentage of this disease as found in various Great Northern selections is presented.

The yields of the various bean selections are always of interest to the bean growers. Yield records of the selections have been recorded since

Table 5.—Yield in bushels per acre of 10 Great Northern bean selections grown on the Buhl plot during 1940[1].

Selection	Plot I	Plot II	Plot III	Plot IV	Plot V	Plot VI	Plot VII	Plot VIII	Average
U. I. 15	43.6	45.4	43.6	43.6	39.9	43.6	36.3	41.7	42.2
U. I. 123	34.5	36.3	36.3	34.5	32.7	34.5	27.2	36.3	34.0
U. I. 81	34.5	38.1	41.7	38.1	37.2	36.3	34.5	30.9	36.4
U. I. 59	27.2	34.5	34.5	30.9	34.5	34.5	30.9	27.2	31.8
C. T. 32-49	32.7	35.4	41.7	40.8	32.7	32.7	34.5	39.0	36.2
C. T. 32-99	39.9	34.5	32.7	39.0	39.9	41.7	39.9	36.3	38.0
C. T. 15-7-1-1	42.7	47.2	43.6	46.3	46.3	45.4	41.7	41.7	44.4
C. T. 15-7-1-4	37.2	39.0	38.1	41.7	42.7	39.9	39.9	36.3	39.4
C. T. 15-7-1-5	39.0	45.4	44.5	42.7	39.9	40.8	43.6	36.3	41.5
C. T. 15-7-3-2	41.7	44.5	44.5	38.1	45.4	47.2	41.7	42.7	43.2

[1]Beans have not been cleaned.

each selection was released to the growers. Table 4 shows the yields given in bushels per acre of three selections since 1934 and of Great Northern U. I. 15 since 1938 when seed was available for larger plantings. The bean plots were not located on the richest soil because of other tests desired and these selections often give much greater yields per acre in commercial bean fields. It is of special interest to note that very poor yields were obtained on the Buhl plot in 1937 where a high percentage of curly top occurred. Little difference in yields occurred during seasons when the beet leafhoppers were few and the percentage of curly top diseased plants low. However, when the curly top disease severely affects the selections susceptible to curly top then the yield is greatly reduced. It is for this reason that Great Northern U. I. 15 may prove of special value in areas formerly affected by the curly top disease. The yields of various Great Northern selections grown on the Buhl experiment plot in a replicated planting are

presented in Table 5 and show that the higher yields were found in those selections which are resistant to curly top.

The number of days it takes for a selection to reach maturity is an important characteristic. This is greatly influenced by the season, type and richness of the soil, and by irrigation and other factors. As shown in Table 6, the number of days for Great Northern selections to reach maturity were found to differ in a replicated planting. The three selections now grown commercially, Great Northern U. I. 123, U. I. 81, and U. I. 59, required about 90 days to reach maturity on the Buhl plot in 1940. Great Northern U. I. 15 required 95 days as also did other resistant selections. This difference in date of maturity has been consistent on other plots for other seasons, although on some plots all selections take a shorter or longer time to mature as a group.

The leaf and vine characteristics of Great Northern U. I. 15 are very similar to those of Great Northern U. I. 123. The foliage is of darker

Table 6.—Number of days to reach maturity of 10 Great Northern bean selections grown on the Buhl plot during 1940.

Selection	Plot I	Plot II	Plot III	Plot IV	Plot V	Plot VI	Plot VII	Plot VIII	Average
U. I. 15	94	95	95	95	95	97	94	95	95
U. I. 123	89	89	90	90	90	90	90	88	90
U. I. 81	88	90	90	90	90	90	90	90	90
U. I. 59	90	93	91	90	90	93	91	93	91
C. T. 32-49	90	90	93	94	93	93	93	94	93
C. T. 32-99	91	91	90	90	94	94	94	94	92
C. T. 15-7-1-1	94	95	95	94	95	97	95	95	95
C. T. 15-7-1-4	94	94	93	94	95	95	95	97	95
C. T. 15-7-1-5	94	95	95	95	94	95	97	94	95
C. T. 15-7-3-2	94	95	95	94	97	95	96	97	95

green on U. I. 15 and the runners are of average length in both selections. The vine growth of Great Northern U. I. 15 is somewhat more vigorous than that of U. I. 123. Seed size, shape, and color are very similar to those characteristics of U. I. 123. Cooking tests indicated that no difference occurred between U. I. 15 and the other commercial Great Northern selections. Soaking tests indicated that U. I. 15 has a smaller percentage of hard seed coats than do the other commercial Great Northern selections listed.

Red Mexican Selections

The western portion of Twin Falls County is of major importance in the production of small red type beans. The common Red Mexican variety was grown in that area until 1937, when two new varieties of Red

Mexican beans were introduced, Red Mexican U. I. 3 and Red Mexican U. I. 34. The common Red Mexican variety, although susceptible to the virus of common bean mosaic, is resistant to curly top and could be grown in this area where beet leafhoppers are usually numerous. The disease of common bean mosaic on the common Red Mexican variety caused a loss in yield each season and often lowered the grade of the harvested crop.

Red Mexican U. I. 3 and Red Mexican U. I. 34 are two selections developed by the bean improvement program and are resistant to both curly top and common bean mosaic. They are hybrid selections from a cross of common Red Mexican and Great Northern U. I. 1.

In Table 7 the yield data of three Red Mexican varieties are shown. Yields may vary somewhat from season to season, but the average yields showed Red Mexican U. I. 3 and U. I. 34 to be larger than those of common Red Mexican. The difference in yield is but one factor to consider. Both new selections have seed that is of a darker red color, a characteristic which the trade desires. Soaking tests indicated that the

Table 7.—Yields in bushels per acre of Red Mexican selections grown on the Buhl experiment plot.

Red Mexican	1936	1937	1938	1939	1940	Average
Red Mexican U. I. 3	53.6	64.8	57.0	36.9	40.8	50.6
Red Mexican U. I. 34	56.8	64.1	43.4	38.9	33.6	47.4
Common Red Mexican	34.1	52.6	48.8	36.5	39.6	42.3

new selections retained more red color than did the common Red Mexican variety. The seeds of the three Red Mexican varieties are very similar in size and shape. Cooking tests showed that the new selections were of equal quality.

Red Mexican U. I. 3 and U. I. 34 have similar vine and pod characteristics, although Red Mexican U. I. 3 has a slightly heavier vine structure than does U. I. 34.

Bean Diseases in Idaho

Although the Idaho bean growers have some very serious disease problems, they do escape some of the most destructive of the bean diseases found in the eastern and southern parts of the United States. The dry climate during the growing season found in the larger bean producing areas of southern Idaho is not conducive to the serious development of those bacterial and fungus diseases which thrive in more humid sections. Due to favorable climate and suitable soil types, the production of seed and dry beans has become of great commercial importance in Idaho. Bean diseases that are of importance in Idaho also occur in other areas and constitute a serious production problem.

Bean diseases found in Idaho are divided into four main groups based on the causal agent of the disease. The groups are virus diseases, bacterial diseases, fungus diseases, and diseases and injuries due to other causes.

The most important of the bean diseases in Idaho are caused by the virus group. Losses due to bean virus diseases were estimated to be 65,000 one-hundred pound bags in 1938 *(6)*. The symptoms of our most important diseases are described.

Virus Diseases

A virus disease is caused by a factor which can multiply in the plant and is transmitted from one plant to another by mechanical means, through the seed, or by means of insects. Although the properties of several viruses that attack beans have been studied, their exact nature is not known. Virus diseases are usually studied by the symptoms they produce on the plant. The virus may be systemic and affect the whole plant, or may cause only a local infection.

Figure 5.—This picture taken early in the season shows a 4-row Bountiful plot in which nearly all the plants are affected with curly top.

Curly Top

During the past few years the curly top *(4)* disease, sometimes called bean "blight", has become of importance to the bean industry of southern Idaho. Severe losses have occurred in both field and garden beans. Stands may be reduced in the field accompanied by a loss in yield or the quality of the crop may be damaged.

The beet leafhopper, *Eutettix tenellus* Baker, is the vector of the curly top virus to several of our important cultivated plants. Many commercially important hosts are susceptible to curly top. Such hosts other than beans are sugar beets, tomatoes, peppers, squash, cucumbers, zinnias, and many other garden and flowering plants. The adult leafhoppers may be pale yellow to dark grey in color and are about one-eighth of an inch long. The adults over-winter on several desert food plants, and in the spring the

Figure 6.—The plants in the foreground have been killed by curly top. This Bountiful plot is the same as that shown in Figure 5, in the center of the picture.

leafhoppers will migrate from the desert breeding grounds to the cultivated areas. One to three generations are produced on the wild and crop hosts during a single season. The beet leafhopper has its range in the arid and semi-arid regions of the western states. Serious outbreaks of this disease have occurred in Idaho during seasons when the leafhoppers are

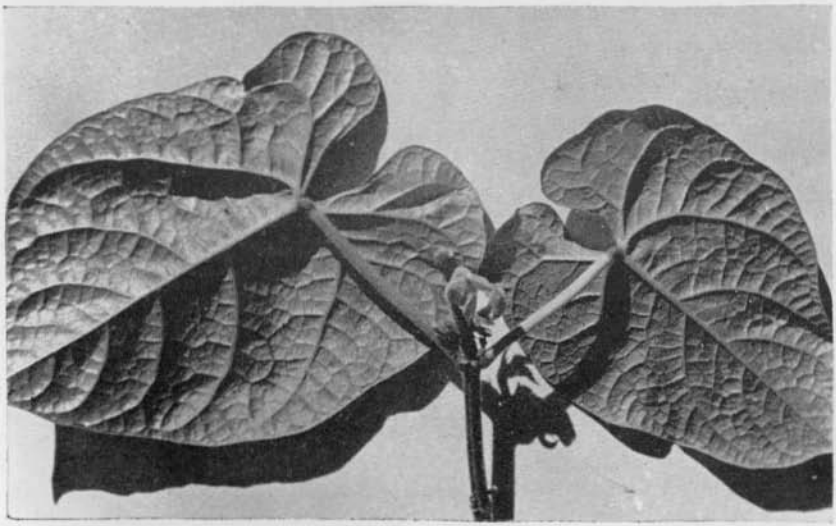

Figure 7.—Bean plant showing early symptoms of curly top. The growing point in the center has been killed.

Figure 8.—Bean plant showing severe symptoms of curly top. Note severely curled small leaves.

especially numerous. Only leafhoppers carrying the virus *(15)* can transmit the disease which is found on both wild and cultivated hosts. A leafhopper must first feed on a plant infected with the virus of curly top before it can transmit the virus to another susceptible plant. Serious damage has occurred in Twin Falls County during several seasons, notably in 1924 and in 1937. Reductions in the yield will vary from a trace to 100 per cent of the crop. Figures 5 and 6 show a plot of Bountiful beans affected by curly top during 1940 at Buhl.

Bean plants of susceptible varieties are more subject to injury while in the younger stages of growth and especially when they are just coming through the soil. On a plant which has only the primary leaves, the growing point of the diseased plant may be killed by the curly top virus and drop off *(Figure 7)*. The plant will then turn yellow and die. Such plants are often covered by healthy plants or by cultivation. The earliest symptoms of curly top on a somewhat larger plant is the downward curling of the first trifoliate leaf *(Figure 8)*. The leaves are comparatively thick and brittle and will break easily away from the stem. Field observations indicate that susceptible bean plants will become infected at any stage in the life of the plant. Plants infected late in the season may show symptoms only in the top of the plant and may survive until the end of the season. The curly top virus is not carried in the seed as in the case of common bean mosiac.

Common Bean Mosaic

Common bean mosaic is a seed borne virus disease. Seed from a severely infected plant may produce the disease in nearly 50 per cent of the plants grown from that seed *(12)*. This disease is also spread in the field from plant to plant by several species of aphids. The most conspicuous symptom of common bean mosaic is the mottling of the leaves *(Figure 9)*. The mottling may form various patterns, but darker green areas may be seen on the lighter green background. The dark green areas may often be seen along the mid-vein. The leaves of infected plants may be curled downward and be slightly cupped. In some varieties the larger portion of the affected leaf will be light green in color and the darker green areas will show as warts or raised blisters on the upper surface of

the leaf. The severely diseased plants are stunted and set few pods which may be later in maturing than the healthy plants. The dwarfing of the plant may be associated with excessive branching forming a more bush type plant than normal. Susceptible bean plants may become infected with the mosaic virus at any time during the season.

Yellow Bean Mosaic

Yellow bean mosaic is not seed borne and at the present time is not a disease of commercial importance in Idaho. The symptoms of this disease should not be confused with curly top or common bean mosaic. The first symptom of yellow bean mosaic is a downward curling of the first trifoliate leaf similar to the downward curling of the leaves of plants infected with curly top. However, soon small light yellow spots develop *(Figure 10)* in the dark green background of the leaves *(11)*. The yellow spots may become larger and gradually spread over most of the affected leaf, giving it a chlorotic appearance. Plants may be only slightly affected by this disease or may be severely stunted. The disease is spread in the field by several species of aphids and is usually more prevalent near the borders of the field.

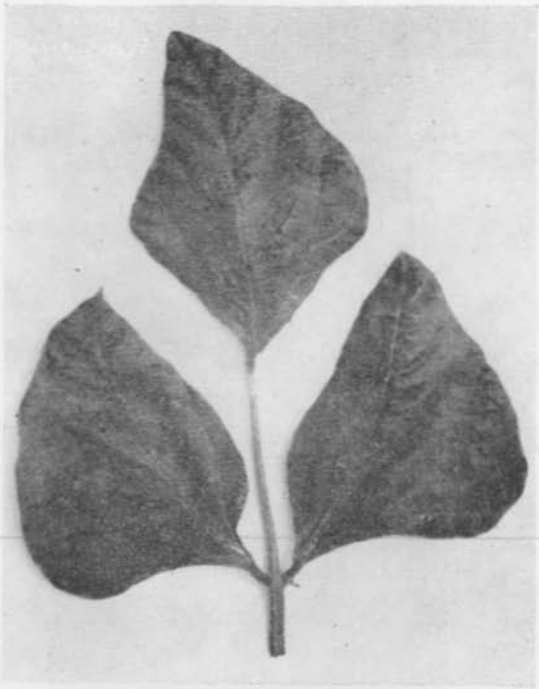

Figure 9.—Symptoms of common bean mosaic on a bean leaf.

Other Virus Diseases

Several other virus diseases are known to occur on beans. These virus troubles at the present time are not of commercial importance. Virus diseases found on tobacco, tomato, peas, alfalfa, red clover, and other crops have been shown to be infective on beans *(11)*. Symptoms of virus-like diseases have also been observed in beans, but the nature of these troubles has yet to be determined.

Control of the Virus Diseases

The best control of the virus disease is in the use of resistant varieties. Several field beans are available and are now in commercial production. Great Northern field beans resistant to common bean mosaic are Great Northern U. I. 123, Great Northern U. I. 81, and Great Northern U. I. 59 *(10)*. These varieties are somewhat tolerant to curly top but will be

severely affected during seasons when the beet leafhoppers are especially numerous. A new Great Northern variety, Great Northern U. I. 15 *(8)*, is resistant to both the viruses of curly top and common bean mosaic and is now available to the growers. Two Red Mexican varieties are available *(9)*, Red Mexican U. I. 3 and Red Mexican U. I. 34, which are resistant to the viruses of curly top and common bean mosaic.

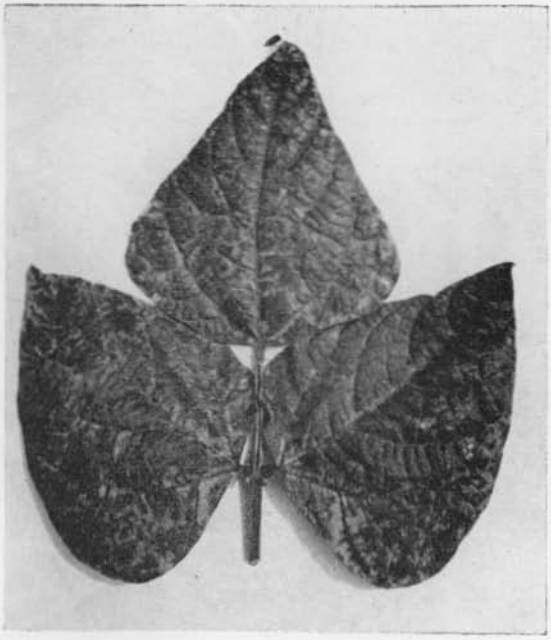

Figure 10.—A bean leaf showing symptoms of yellow bean mosaic.

Garden bean varieties resistant to the virus of common bean mosaic include Idaho Refugee and Wisconsin Refugee *(13)*. Garden beans are, as a group, very susceptible to curly top and are planted well inside the farming area and at a distance from the breeding grounds of the beet leafhoppers. During years when the beet leafhoppers are very numerous, severe damage may occur on any portion of the bean growing area. A number of garden bean selections of various types which are resistant to the viruses of curly top and common bean mosaic have been developed by this program. After canning tests and further field trials, the most promising of these selections may be released to the bean growers. Many garden varieties are tolerant to the virus of common bean mosaic and by rogueing diseased plants from the seed field this disease can be prevented from causing severe damage. Yellow bean mosaic and other virus diseases are not of great commercial importance.

Bacterial Bean Diseases

Common Bacterial Blight

Although common bacterial blight is of occasional importance in the northern bean growing areas in Idaho, it is of minor importance in the irrigated areas in southern Idaho. This disease is seed borne and infected seed from other areas where bacterial blight is severe is often planted in our producing areas with loss to the resulting crop. Seed produced in southern Idaho is usually entirely free of this disease and for this reason our garden bean seed finds a market in the eastern and southern sections of the United States.

Common bacterial blight in beans is caused by the bacterial organism, *Bacterium phaseoli* E. F. S. The symptoms of this disease can be recog-

nized in the field and consist of water-soaked lesions on the leaf which become brown and brittle and may be surrounded by a yellow border *(3)*. The water-soaked lesions on the pods are usually slightly sunken and brick-red. The bacterial exudate may form a crust on the leaf and stem. The plants are severely stunted and wilted and may be girdled and break off at the nodes. The disease is carried by the seed and yellowish spots may appear on light colored seeds. The growing tips of new plants are sometimes killed in the field. The organism will overwinter in seed and bean refuse. The organism thrives under moist and humid conditions and can be disseminated in the field from plant to plant by spattering rain drops.

Halo Blight

Halo blight is another bacterial disease and is caused by the organism, *Bacterium medicaginis* var. *phaseolicola* B. The symptoms are very similar *(Figure 11)* to those of common bacterial blight but may be distinguished by a large chlorotic halo surrounding the lesions which are commonly produced on the leaf. This disease is also of occasional importance in northern Idaho. The bacteria are seed borne and diseased seed should not be planted. The diseases of common bacterial blight and halo blight may be found together in the commercial bean fields. Halo blight also does the most damage under a condition of high humidity which is conducive to the spread of the organism.

Fusarium Root Rot

This disease is caused by a soil borne fungus called *Fusarium solani* var. *martii* (A. and W.) f. 3 Snyder. The most distinguishing symptom is the reddish discoloration of the tap root of the bean plant *(2)*. The discoloration may affect the whole root or appear in streaks which may show above ground. The lateral roots will often be killed and force new lateral roots to arise which are usually formed above the affected portion. The plant above ground may show a gradual stunting, and the leaves may turn yellow and die. The maturity of the plant may be hastened by the effects

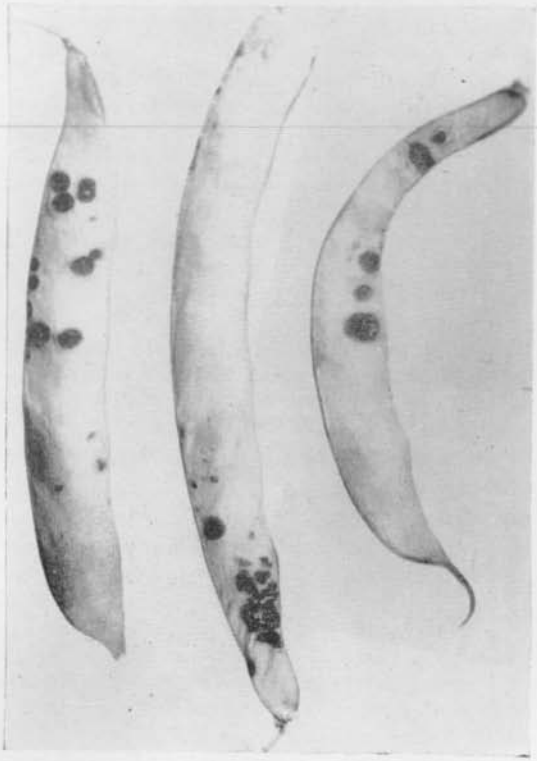

Figure 11.—Symptoms of halo blight on bean pods.

of the disease. This disease is one of the most important and widespread of the root rot diseases in beans. The organism is found in bean producing areas in Idaho, although damage from this disease does not prevent good yields from being obtained.

Rhizoctonia Root Rot

This disease is caused by the fungus, *Corticium vagum* B. and C., and is identical with the organism causing the rhizoctonia disease on potatoes. The disease affects the tap root of the bean plant in a similar manner to that of fusarium root rot and the symptoms are also quite similar. The lesions on the bean tap root and stems show as brick-red areas but which have a definitely outlined lesion.

Sunscald

Sunscald may produce a spotting and streaking of the pods of bean plants as well as streaking of the stems and branches. Small spots will first appear on the pods followed by streaked brown and red discolorations *(7)*. The spots may enlarge until a large area of the pod may be affected. Losses do not usually arise in beans due to sunscald.

Baldhead

When the growing point of the new seedling is killed by injury and one or both of the primary leaves have been detached from the stem, the resulting seedling is called a baldhead plant. A bean seed consists of a small dormant bean plant surrounded by a thin seed coat. During germination this dormant plant renews its growth and develops into a bean seedling having a primary root, hypocotyl, two cotyledons, the first two leaves called the primary leaves, and the stem growing point *(1)*. Since all these structures are present in a seed bean, it is possible for them to be injured during handling, threshing, or cleaning. Reducing the speed of threshing machines or using improved types will aid in the prevention of seed injury. This injury may show in various ways, but a common one is called baldhead. The plant may be killed, but if not it does not develop into a normal producing plant during the season. One to three per cent of baldhead has been observed in Great Northern beans on the experiment plots. Baldhead can be much more severe in garden varieties and occasionally causes loss of commercial importance.

Other Causes of Injury in Beans

Heat injury is also a cause of some damage in beans. High temperatures associated with heavy irrigation may cause damage to the growing crop. Heavy irrigation or standing water often cause trouble in portions of the bean field. Severe storms and especially hail storms often damage a section of the bean growing area. Beans that have been hailed early in the season often recover and produce a good crop, but hail storms later in the season can cause a substantial loss of the crop. Excess applications of commercial fertilizers have caused damage in beans. In Idaho beans have not responded to commercial fertilizer as have bean crops in other areas. Some increase in yield has been reported from the use of nitrogen fertilizers. Early spring and fall frosts have sometimes caused a substantial loss in beans. Late maturing fields have been severely injured by

frost or freezing, causing a reduction in the yield, grade, and quality of the crop. Heavy rainfall during harvest can also be a factor in reducing the yield and quality of the bean crop.

Summary and Conclusions

The production of seed and dry beans is of major importance in Idaho. Great Northern and Red Mexican are two commercial classes of dry beans that are of special importance.

The program for bean improvement has resulted in the development of several Great Northern varieties which are resistant to the virus of common bean mosaic. Great Northern U. I. 15, the most recent Great Northern variety released, is resistant to the viruses of curly top and common bean mosaic. Two Red Mexican selections, Red Mexican U. I. 3 and Red Mexican U. I. 34, have recently been released and are resistant to the viruses of curly top and common bean mosaic. Many promising selections of various field and garden beans are still under test but more work is needed before these may be released to the Idaho bean growers.

Vine, pod, and seed characteristics of Great Northern and Red Mexican selections are described.

Yields of the various selections tested are presented. During seasons when curly top damage was severe, the yields of Great Northern U. I. 15, which is resistant to the viruses of common bean mosaic and curly top, were found to be greater than the yields of Great Northern selections susceptible to curly top. Great Northern U. I. 15 may prove to be of special value when grown in areas usually severely infested with beet leafhoppers.

Data are presented, showing the percentages of curly top, common bean mosaic, and yellow bean mosaic. Data showing length of growing season of several Great Northern bean selections are also presented.

The yield data of Red Mexican U. I. 3, Red Mexican U. I. 34, and common Red Mexican are also presented, showing that a larger yield was obtained for the selections resistant to common bean mosaic.

Symptoms of bean diseases that are of importance in Idaho are described and their control measures discussed.

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