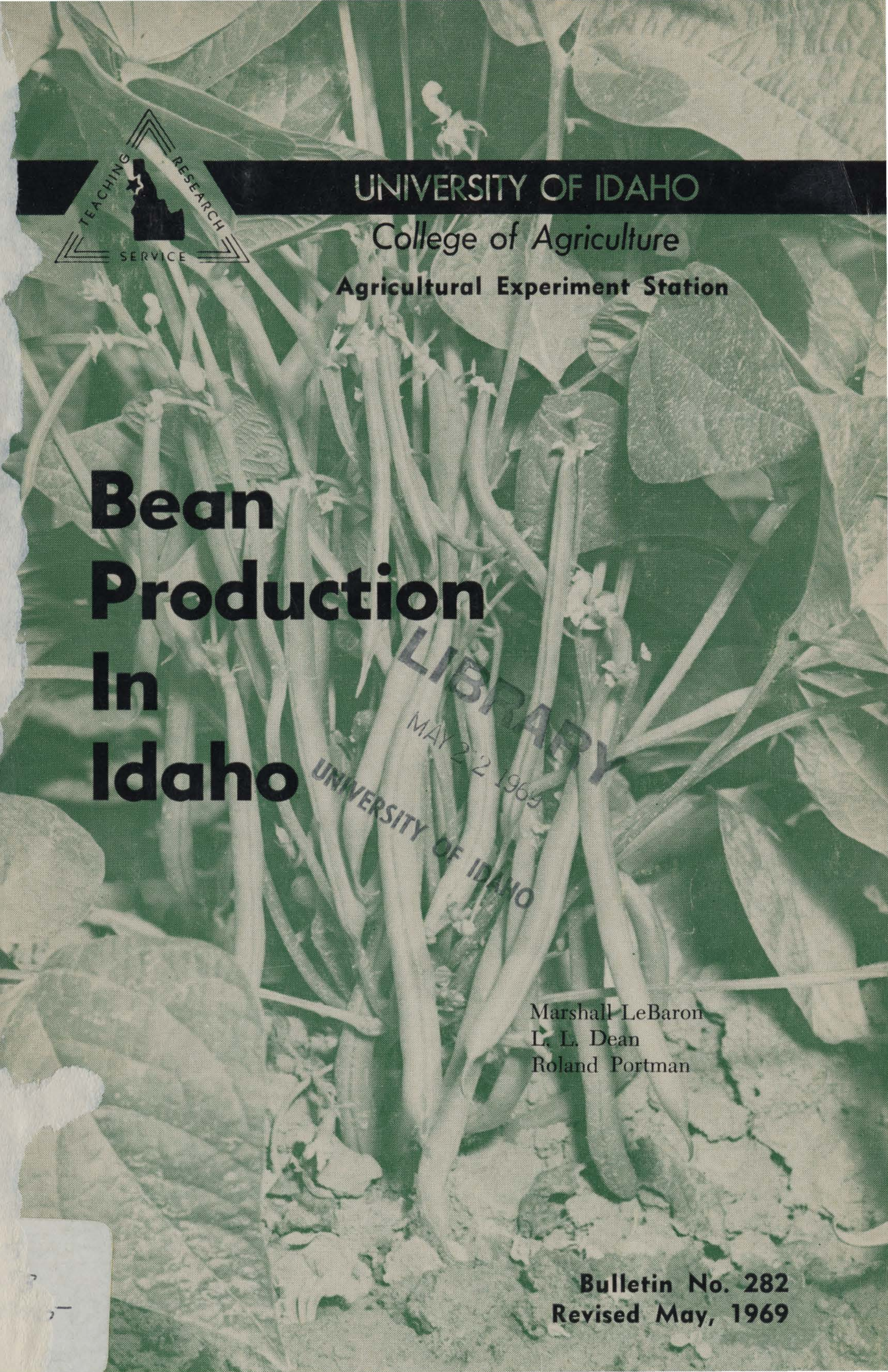

UNIVERSITY OF IDAHO

College of Agriculture

Agricultural Experiment Station

Bean Production In Idaho

Marshall LeBaron
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Bulletin No. 282
Revised May, 1969

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Varietal Reaction to Bean Diseases

Field or Dry Beans

Variety	Curly Top	Common Mosaic Strain VI	Common Mosaic Strain V1A
California Pink (Sutter)	Resistant	Susceptible	Susceptible
Cranberry	Susceptible	Susceptible	Susceptible
Great Northern 1140	Susceptible	Resistant	Resistant
Great Northern UI-31	Resistant	Resistant	Resistant
Great Northern UI-59	Susceptible	Resistant	Resistant
Pea Bean Michelite 62	Susceptible	Resistant	Susceptible
Pea Bean Sanilac	Susceptible	Resistant	Susceptible
Pinto UI-111	Resistant	Resistant	Susceptible
Pinto UI-114	Resistant	Resistant	Resistant
Red Kidney (Dark)	Susceptible	Susceptible	Susceptible
Red Kidney (Light)	Susceptible	Susceptible	Susceptible
Red Mexican U1-34	Resistant	Resistant	Susceptible
Red Mexican UI-36	Resistant	Resistant	Resistant
Red Mexican Big Bend	Resistant	Resistant	Resistant

ABOUT THE AUTHORS

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Bean Production in Idaho

Introduction

Beans have historically been produced in southern Idaho for seed of both field (dry-edible) and snap (garden) bean types as well as for food. In recent years a limited acreage has been devoted to the production of green beans for processing. Lima beans for processing have been grown in Western Idaho for a number of years.

The major bean production area in Idaho extends along the Snake River from southcentral to southwestern Idaho. The production is centered in Twin Falls and Jerome counties in the southcentral section and in Canyon County in the southwestern section. The soils are predominantly silt loams with sandy loams in some localized areas. The extent of bean production in this general area is limited by the length of the frost-free growing season, irrigation, high temperature and the curly-top virus.

Average annual bean seed production (1959-67) in Idaho is estimated to be 1,866,000 cwt. of field beans and 365,000 cwt. of snap bean seeds. This represents nearly 25-million dollars gross annual income to Idaho farmers.

The information presented in this bulletin will be useful to persons interested in general bean production problems. Included are observations and ideas used by successful bean growers as well as research data from the Experiment Station. New ideas that seem to have merit but which are not now in general use are also presented. Chemicals used for weed and disease control and fertilizers are not mentioned by name since more current information is often available from the Extension Agricultural Agent or commercial sales representatives.

This bulletin deals with bean production under irrigation only, which includes sprinkler as well as surface applied water.

Varieties

The principal dry bean types produced in Idaho include varieties of Pinto, Great Northern, Red Mexican (small red) and California Pink. Varieties of kidney, pea bean (small white) and cranberry are also produced in limited quantities. These varieties all have a semi-vining growth habit, except kidney bean and a pea bean variety, Sanilac.

The relative yield and days required from planting to maturity for representative types from each major class of dry beans are presented in Table 1. The data were obtained from tests at the University of Idaho's Agricultural Experiment Station at Kimberly, Idaho.

Table 1. Relative yield and growing season of dry beans in Idaho.

VARIETY	Yield Average Lbs/A	Years in Average	Days to Maturity
Red Mexican UI-34	2519	16	106
Red Mexican UI-36	3146	5	96
Big Bend	3100	3	103
Pinto UI-111	2646	17	91
Pinto UI-114	3140	6	95
Great Northern UI-59	2240	11	95
Great Northern UI-61	2250	4	95
Great Northern US-1140	2615	12	89
Sanilac (pea bean)	2360	7	96
Light Red Kidney	2290	4	99
Dark Red Kidney	1780	5	98
Cranberry	2070	3	99
Sutter Pink	2970	3	96

There are many snap bean varieties produced for seed in southcentral Idaho. Lima beans as well as limited acreages of snap bean varieties are produced for seed in southwestern Idaho. These varieties vary in type, yield and maturity and are grown only under contract with a seed company. Detailed information on specific snap bean varieties can be obtained from seed companies. Most of the recommeded farming practices for field beans will also apply to snap beans.

Source of Seed

Field bean seed should always be of certified grade. Each bag of certified seed sold in Idaho must bear the official seal and tag of the Idaho Crop Improvement Association. This tag and seal assures the grower, within stated limits, that the seed is of good quality and that it is free of varietal mixtures, seed-borne diseases, objectionable weed seed and will meet the 85 percent minimum germination requirement.

Foundation seed stocks of approved varieties are produced and maintained by the Idaho Agricultural Experiment Station and are distributed to warehousemen and growers through the Idaho Crop Improvement Association. The list of approved varieties changes periodically, depending upon seed demand and the introduction of improved varieties. An up-to-date list is kept by the Idaho Crop Improvement Association.

Certified seed for planting may be purchased from warehouses in the production areas. Seed of snap bean varieties is not certified but high-quality stocks are maintained and produced by the major commercial companies in the area. All snap bean seed presently planted in Idaho shall have an "In-State Planting Certificate" certifying it to be free from seed-borne bacterial diseases.

At the present time there is an embargo prohibiting the importation of seed into Idaho from foreign countries and, except for specific conditions stated in Idaho code, this embargo includes the United States east of the Continental Divide.

Crop Rotation

Beans will fit into a variety of rotation plans. They may be grown satisfactorily following alfalfa, clover, cereals, potatoes, peas, rye or sugar beets. Many fields have produced good bean crops for two or more years. However, the successive cropping of beans on the same field year after year is not recommended. This practice multiplies the disease and insect problems and reduces soil fertility and organic matter. A crop rotation that allows at least two years between bean crops on a particular field is considered a good practice.

Growers are looking for ways to shorten their rotation so that cash crops appear more frequently. Alfalfa is not essential to a good rotation if organic matter is maintained in some other way. A bean-cereal rotation is a very satisfactory one if properly executed. When winter wheat is used, the harvest should be followed immediately by irrigation and plowing to assure the most rapid and complete decomposition of the straw possible. In the bean producing areas, plowing should be completed no later than September 1. When a spring cereal is used, the completion date may be a few days later.

Some bean growers have used winter cover crops such as fall-planted rye plowed down just before planting. An experiment conducted over a six-year period at the University Experiment Station at Kimberly, Idaho, has shown bean seed yield to be equal when continuous beans were grown with and without a cover crop each year. Therefore, the use of cover crop is not recommended except if it is needed for control of wind erosion.

Fertilization

Phosphorous and zinc fertilizers in the proper amount and combination are essential for good yields of bean seed and should be included in any bean production program in Idaho. Zinc deficiency of beans occurs most often following heavy phosphate or manure application or after sugar beets. If fields have been leveled, zinc deficiency may show on spots where the highly calcareous subsoil has been exposed. The residual phosphorous level of the soil is often too low for beans even where it has been applied regularly on prior crops. The two fertilizer elements must be incorporated into the top four-six inches of soil for reasonable results.

Nitrogen is not generally needed for beans unless a large amount of crop residue returned to the soil has not decomposed sufficiently to release nutrition for the bean plant.

A soil test is the most accurate way of determining the phosphorous needs of the soil for beans. There is no satisfactory test method available to truly predict the availability of zinc in the soil at this time.

A bean crop may exhibit zinc deficiency after it has emerged, which can be readily corrected by a foliar application of zinc during the first six weeks of growth or until about July 15 in southern Idaho. After this time the chances for success diminish very rapidly. To correct this deficiency use a foliar application of 2½ pounds of zinc per acre. Zinc sulphate or other soluble organic and inorganic sources are suitable for foliar application.

Minimum fertilizer application rates are outlied in Table 2. Recommendations are based on soil tests and field trials. Procedures for soil testing are available from the Extension Agricultural Agent.

TABLE 2. Fertilizer recommendations for bean seed production in Idaho.

ELEMENT	Soil Test (CO_2)		Apply, Minimum	
P	0-9 lbs/A	(20)*	50 lbs/A	(115)
	9-18	(41)	30	(69)
	18-above		NONE	
Zn	5 lbs/A each year of beans.			
	10 lbs/A every third year for continuous beans.			
N	80 lbs/A new desert soils.			

*Phosphorous expressed at P_2O_5.

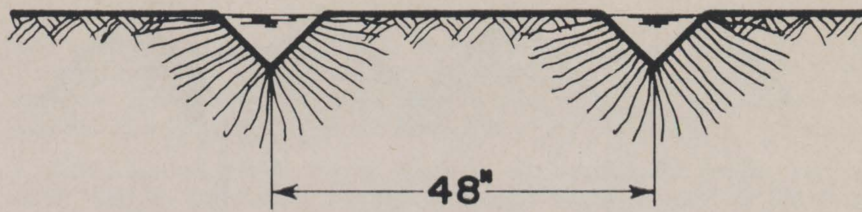
Inoculation

The inoculation of bean seed with nitrogen fixing bacteria has not proven to be of value in the bean producing areas of southern Idaho except for the first bean crop on the virgin desert soils.

Land Preparation

The preparation of land for beans varies with the machinery available and the preceding crop. The land is plowed either in the fall or spring. If a winter cover crop or plant residue is to be turned under, the land should be plowed by early May. When beans are to follow alfalfa, the alfalfa may be crowned in the fall, followed by deep plowing in the spring. Another very satisfactory method of handling alfalfa for beans is to spray the alfalfa with 2,4-D at the rate of two pounds per acre (acid equivalent) after the last cutting of hay is removed in the fall. The alfalfa will be killed within a period of two weeks and may then be plowed without crowning.

Two methods of seedbed preparation are commonly used, with the pre-plant irrigation an important step in either method. In the first method, after a pre-plant irrigation, the soil is allowed to dry for approximately ten days or until the surface is dry. The usual practice is to harrow once, then work the soil with a disk or field cultivator to a depth of three or four inches. The final seedbed preparation can then be accomplished by harrowing two or three times.



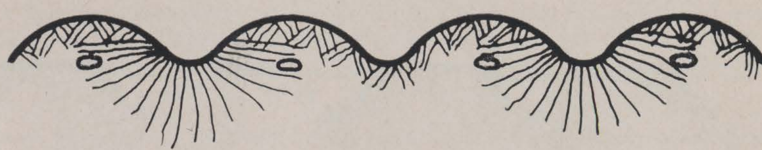


Figure 1a. Shallow corrugates used to prepare soil for pre-plant irrigation.

The second method of seedbed preparation is a modified procedure which uses the principle of "bedding" for the pre-plant irrigation. One procedure is to put shallow corrugates (3 inches) at the spacing (48 inch) that will be used for the crop production season (Fig. 1a). The field is then soaked laterally from the corrugates to a point just beyond where the seed is placed when planting.

It is sometimes advisable to harrow once before planting to remove germinating weed seedlings. A cultivator shovel is often placed so that it will operate very shallow just ahead of each planter, which also eliminates germinating weeds. A second procedure for bedding is to put deeper corrugates (6 inch) at the 24-inch spacing which can be done earlier in the season if desired. The pre-plant irrigation water will be applied in every other corrugate or again at the 48-inch spacing (Fig. 1b). The ridges are partially leveled down by harrowing and again a cultivator shovel is placed to operate ahead of each planter. All procedures are the same from this point on, that is, the post-plant hilling and harrowing off of the ridges.

If a pre-emergence weed chemical is used, shallow corrugations are best to assure that untreated soil will not be turned to the surface.

Some of the advantages of bedding over the older procedures of seedbed preparation are: (1) Reduced tractor time to prepare the seedbed; irrigation is used to firm up the soil rather than tillage. (2) The wider space between corrugates makes it possible to bring soil moisture to a proper level for bean planting with less water and without excess soaking of the soil.

The grower must decide how his equipment and farming methods can be adapted to the above procedures of land preparation.

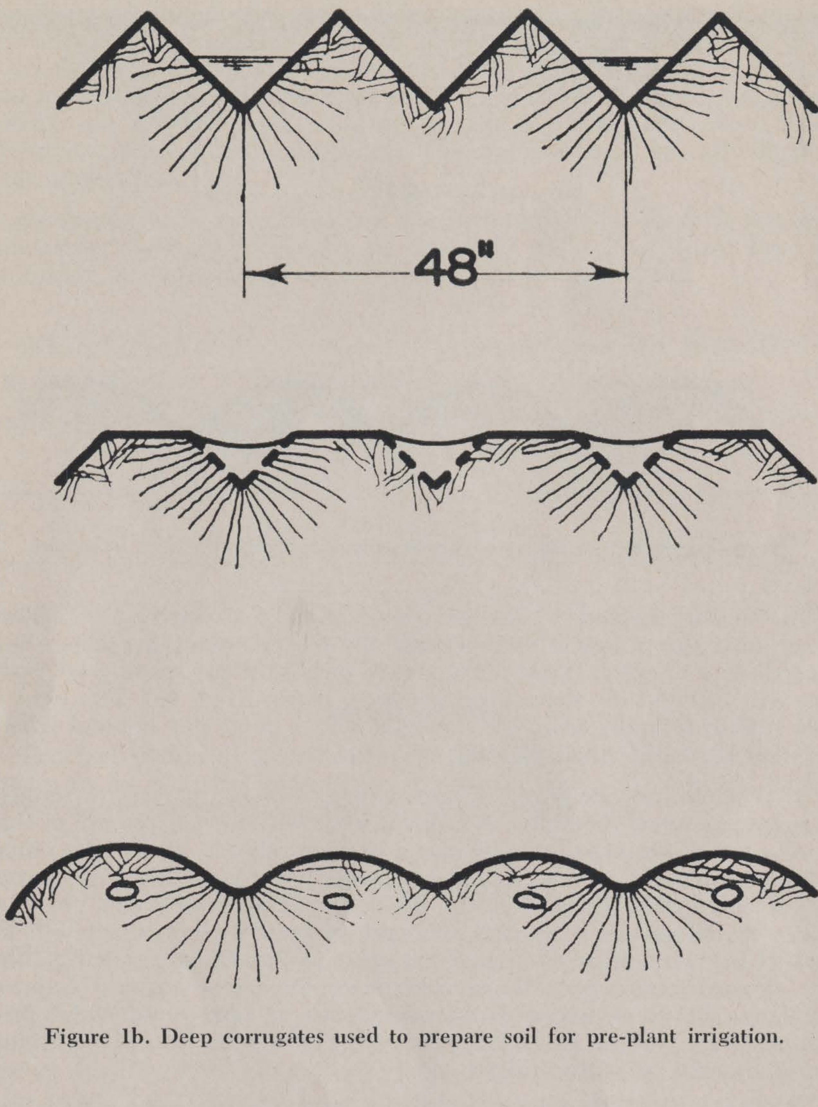


Figure 1b. Deep corrugates used to prepare soil for pre-plant irrigation.

Weed Control

The principal reason for cultivating a bean crop is to control weeds. Excessive cultivation will result in undue injury to the root system. The cultivation should be shallow and should be started when the weeds are small. Corrugations between the rows for irrigation water are made simultaneously with the first or second cultivation, or at planting time in solid stands of beans.

The cultivators may be set up with many different combinations of tools and any combination that will till the soil surface and roll some soil around the base of the plant will be satisfactory. Ridging of some soil around the base of plants is necessary for two reasons: first, it will help promote the growth of secondary roots which are vital when the primary root system becomes affected by root rot; second, it will smother the small weeds in the bean row.

Most annual weeds, except those in the nightshade family, can be controlled by cultivation. Nightshade plants begin to grow at the close of the cultivation season and are large and green at harvest; the plants interfere with the harvest operation and the berries will stain and spoil the seeds in storage. The nightshades can be controlled by some of the weed chemicals, but if not, the plants are often removed from the windrow by hand.

If it becomes necessary to use 2,4-D in the spring for perennial weed control or to chemically crown alfalfa before beans are planted, wait at least 7 days, but preferably 10-14 days, then plow and prepare the seed bed.

Many new pre-emergence weed control chemicals have been developed and have given satisfactory results in many cases. Their use can be of benefit to the bean grower if: (1) there is a potential weed problem great enough to warrant the expense, (2) their use will reduce tractor time, (3) they will eliminate late-season cultivations which damage root systems, and (4) close row planting is practiced (see planting section). The choice of chemicals to use will vary with species of plant to be controlled, the effect on the following crop, the cost of material and compatability in mixtures with other materials. It is essential that LABEL INSTRUCTIONS BE FOLLOWED to insure beneficial effects without crop loss.

Planting

Several types of planters are used for beans and all are quite satisfactory. Beans should not be planted until the surface six inches of the soil has reached a temperature of 50° or more. The most common planting dates are from May 15 through June 7.

To insure that adequate moisture is available for germination, seed should be planted at a depth of $2\frac{1}{2}$ to $3\frac{1}{2}$ inches. If the moisture supply is very low, deeper planting should be made. Many growers in southern Idaho make a ridge of soil over the row at planting time. The ridge must be harrowed off within 4 or 5 days to prevent injury to the emerging seedlings. This procedure helps to maintain moisture around the seed and is also effective in weed control.

The optimum planting rate for the commonly used 22 and 24-inch row spacing for the semi-vining field beans should be a spacing of three inches within the row; the snap bush beans should be at a spacing of two inches within the row. If a wider row spacing is used, the spacing between plants within the row should be reduced so that the plant population per acre will remain the same as for the 24-inch row. As the row spacing is reduced below 24 inches the plant population should be increased. The closer spaced rows will bring about a redistribution of the plants so that they are more equi-distant one from the other. This has increased the yield of seed of both field and garden beans by amounts up to 20 percent. Suggested planting rates and row spacings which result in varied plant populations for typical dry and snap bean types are summarized in Table 3. It can be seen that there are many combinations of row width and spacing within the row that can be used to produce the desired number of plants per acre or square foot.

TABLE 3. Variations in plant population when the spacing between rows and within rows is changed.

Spacing between rows in inches	Spacing within the row in inches	Lbs/Acre* planted	Plants Sq. Ft.	Population Plants/Acre
Dry Beans				
24 inch (standard)**	3	75	2	87,000
24 inch (standard)	2	110	3	130,000
20-14-20-14 inch	3	110	3	130,000
20-14-20-14 inch	4	75	2	87,000
Snap Beans				
24 inch**	2	110	3	130,000
20-14-20-14 inch	2	145	4	174,000
20-14-20-14 inch	3	110	3	130,000
6 inch (6×6)	6	145	4	174,000

*Based on 1200 seeds per pound with 100% germination.

**Common row width and within row spacing now used.

Occasionally a farmer is faced with the problem of a poor stand of beans and he must decide whether or not to replant his crop. In making this decision several factors must be considered: (1) is there sufficient time to replant and mature the crop, (2) is there sufficient moisture in the soil surface to germinate the seed, (3) how many plants constitute a stand, and (4) is the reduction in stand uniform or spotty as in the case of frost damage?

The semi-vining field beans will normally produce a good crop if the plant population is not reduced beyond an average spacing of 6 inches between plants in 22-24 inch rows, and even greater spacings will often produce a fair yield. The snap bush beans will normally produce a good crop if the plant population is not reduced beyond an average spacing of 4 inches between plants in 22-24 inch rows.

Irrigation

The use of proper irrigation practices is as important as any cultural practice used in a successful bean production program. There must be adequate moisture for emergence and early growth of the bean seedling. The first irrigation is very important and must be applied before the plants are under stress. This will usually be after about 25 growing days. Soil moisture should not be allowed to drop below the 60% available level throughout the active growing period of the plant to insure uniform growth and pod development. A typical time schedule for irrigation of snap and field beans might be as follows:

	Snap Beans	Field Beans
Planting Period	May 20-30	May 20-30
First Irrigation	June 25	June 25
Second	July 8-10	July 10
Third	July 15-17	July 18
Fourth	July 22-25	July 26
Fifth	August 1-3	August 10
Sixth	August 12-15	August 25*
Seventh	August 25-30	
Eighth	September 10-15 – except if maturity is near.	

*for late maturing varieties only.

The field beans usually require two to four fewer irrigations throughout the season, which results in more time between irrigations.

Both yield and maturity of beans were influenced by irrigation frequency in irrigation studies conducted at the Twin Falls Experiment Station and summarized in Table 4. These studies were conducted with snap beans but the data are equally applicable to all varieties grown in Idaho.

When water penetration into the soil is limited, it can be increased by irrigating in alternate rows each successive irrigation.

TABLE 4. Irrigation treatment effect on yield, consumptive use, and maturity of snap beans.

Soil Moisture Level		Number of Irrigations			Water Use	Yield	Maturity
Planting to Bloom	Bloom to Maturity	Before Bloom	After Bloom	Total	(inches) Total	cwt/A	
High	High	4.3	3.7	8.0	11.92	25.2	Early
	Low	4.3	1.3	5.7	9.09	21.7	Very Early
Low	High	2.0	3.7	5.7	11.18	23.8	Very Late
	Low	2.0	1.3	3.3	8.18	19.8	Late

Sprinkler irrigation is used to a limited extent for bean seed production in Idaho. The problem of diseases associated with sprinkler irrigation limits its use to edible bean seed and processed green bean production. The Idaho Crop Improvement Association regulations forbid certified seed production under sprinkler; companies contracting for snap bean seed production generally do not write contracts if sprinkler irrigation is to be used.

Harvest

Harvesting is a very important step in the production of a bean seed crop. The dry, ripe bean seed must be handled as gently as possible to prevent injury and loss of germination. The beans should be cut and windrowed when the moisture content of the seed is 40% or greater. At this seed moisture, most varieties will have approximately 80% of their pods showing yellow and mostly ripe. As the seed moisture at cutting goes below this level, harvest losses from shattering and mechanical damage will increase.

After the beans are pulled or cut, they should be raked into windrows immediately with a side delivery rake. It is advisable to make the windrows as large as can be conveniently threshed by the specific machine to be used, usually six-eight rows. The larger windrows offer the seed more protection from injury and discoloration by the sun. The pulling and windrowing is often done at night or early in the morning when the plants are damp with dew. This will very materially reduce the loss from shattering. The windrows should be left to cure for a period of seven-ten days to permit complete drying of the straw and pods before threshing.

If the plants are allowed to dry too long before threshing, germination of the harvested seed may be lowered; but more often this results in an increase of seedlings classed as showing slight to moderate injury. Therefore, it is to the grower's advantage to thresh the beans as soon as the seeds can readily be separated from the pods.

Various types of combines are used to thresh beans. Small "all-crop" type harvesters are used by many growers, but large machines developed especially for beans are commonly used in the bean-producing areas of southern Idaho, especially for threshing snap bean varieties.

The care of the seed must begin at the thresher. The cylinder speed should be reduced as much as possible and long drops in the separating and loading operations should be prevented. The cylinder speeds between 250 and 400 RPM are satisfactory for most threshing conditions. Clearance between the cylinder and concave bar should allow the seed to pass through without injury. If there is evidence of injury or splitting in the seed, immediate adjustments should be made. Care in threshing will result in higher quality beans and greater net return to the grower.

Beans for seed purposes may be put into bags or bulk boxes at the combine. Commercial edible beans are usually handled in bulk boxes or by direct truck bulk methods for delivery to the warehouse. The warehouse will mill, pick by hand or electric eye, and generally prepare the beans for the seed or edible bean market. Seed beans are usually bagged in 50 lb. units. Edible lots may be in small packages, 50 or 100 lb. bags, or kept in bulk storages.

Diseases

Wherever beans are grown they are subject to a number of diseases that reduce production and lower the grade of the bean crop. Idaho growers, however, have a well-earned reputation for producing high-quality, disease-free dry-edible and snap bean seed. In part, this reputation rests upon the fact that seed produced in the state is relatively free from infection by certain destructive seed-borne diseases. The comparatively dry climate in our bean-producing areas restricts the spread and development of a number of these serious seed-borne disease-producing organisms. Varieties of beans having high resistance to some of the serious virus diseases have been developed and distributed in Idaho thereby helping to establish the bean seed production industry in Idaho.

In this brief discussion only the most important bean diseases as they occur in the state will be described. They will be listed in four classes based upon the cause of the disease: bacteria, fungi, viruses, and non-parasitic abnormalities.

BACTERIAL

Halo blight, common blight, and **bacterial wilt,** are important diseases of beans caused by bacteria. These bacterial diseases are usually controlled by planting seed free of the bacteria that cause these diseases. Idaho had been, until 1963, largely free from all the bacterial pathogens of beans. In fact, it was believed that infected seed stocks could be freed of these bacterial pathogens by growing them for three successive generations under the usually arid conditions of southcentral Idaho and with furrow irrigation. Seed infested with these bacterial pathogens was repeatedly introduced into Idaho for the specific purpose of eliminating the disease, and this practice appeared to be quite effective.

Figure 2. Sympton of common blight on leaf.

Figure 3. Symptom of halo blight on leaf.

With the occurrence of extensive halo blight in Idaho from 1963 through 1966, this practice is no longer permitted. Bean seed now must be found to be free of bacterial pathogens (either through field inspection or laboratory examination) before it can be legally planted within Idaho. These bacteria are carried in and on the seed from year to year. They are transported from plant to plant and field to field by machinery, animals, insects, and wind-driven rain or hail.

For more detailed information about halo blight, refer to Idaho Agricultural Extension Service Bulletin 444.

Bacterial brown spot is reported to cause severe damage to beans in Wisconsin, but in Idaho it has been observed only in two fields during one season. It is believed, therefore, to occur rarely in Idaho.

Common bacterial blight and halo blight, when widespread and causing severe damage to infected plants, are quite easily recognized. If only a few plants are infected and rain or hail does not occur, these diseases may be difficult to find even when present.

Both diseases are characterized by water-soaked spots on the leaves, pods, and stems of infected plants. Infected tissues become a reddish-brown color and bacterial exudate usually forms on the lesions. Severely affected plants frequently die. Halo blight infection usually results in general yellowing of the plant, and common blight causes a rapid browning of the invaded tissue.

The seeds that develop in infected pods may be invaded by the bacteria at the point of attachment to the pod. Invaded bean seed usually do not appear different from non-invaded seed. Occasionally infected seed may be shriveled or discolored. However, it is usually not possible by ordinary visual examination to distinguish infected from non-infected bean seed.

Seedling bean plants when diseased with bacterial wilt usually are killed soon after emergence. When infection occurs in older plants, the first sign of the disease is a slight wilting during periods of high temperature followed by recovery during periods of lower water stress. Wilting becomes progressively more severe with time and the plant usually turns brown and dies.

Occasionally bacterial wilt does not cause the typical wilt phase but develops leaf symptoms much like common blight. The wilt bacteria spread throughout the plant, invading the pods and developing seeds. Conspicuous lesions are not formed on the stem or pod as occurs with halo or common blight. The suture of invaded pods may be darkened, however, and occasionally invaded seed shows an inconspicuous yellowing of the seed-coat near the point of attachment to the pod. Bacterial wilt is not reported to cause an accumulation of exudate as does halo and common blight.

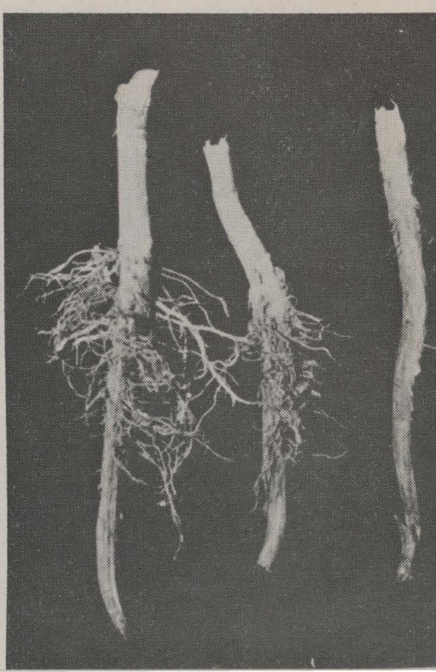
Bacterial brown spot lesions are described on leaves as being brown, necrotic, varying in size, without halo and never transparent or water-soaked. Pod lesions are generally dark green with a small brown center. Frequently pods are bent at a sharp angle at the lesion. Pod lesions are also reported to occasionally be irregular, dark reddish-brown, and sunken.

The bacterial blights and bacterial wilt can be successfully avoided by use of disease-free seed. Foliar sprays for control of these diseases are of doubtful value. At the present time in Idaho infected crops are subject to destruction to curtail spread. Some dry-edible bean types are apparently more resistant to infection than are others. No completely resistant varieties are presently available.

FUNGUS

Root rots occur in varying degrees wherever beans are grown. A number of different parasitic organisms may attack the base of the stem, the tap root, or other parts of the root system causing reduced vigor or death of the entire plant. Dry root rot caused by a Fusarium fungus is more prevalent in Idaho. This disease is widespread and may be quite destructive, especially on soils which have been repeatedly planted to beans without proper rotation of crops. Characteristic reddish discoloration of the tap root is the most constant symptom of the disease. The fungus parasite plugs the vascular tissue of the root. Also, the lower portion of the root is destroyed. If sufficient moisture is present in the surface soil, and the soil is ridged up around the stem, new roots

Figure 4. Bean roots showing severe symptoms of bean root rot.



may develop above the point of injury. More frequent irrigations are required under these conditions.

Although numerous materials have been tested as soil fumigants and as soil and seed-treating agents, none has proven to be entirely satisfactory in controlling root rots. Cultural practices that provide good conditions for plant growth and a crop rotation system in which beans do not follow beans on the same ground are the best insurance against losses from bean root rots.

Sclerotinia Wilt (white mold) has become an important disease in Idaho. It is probably world-wide in its distribution. As the fungus causing this disease is soil-borne, Sclerotinia wilt, like the bean root rots, is usually more serious in the older bean-growing areas. The Sclerotinia fungus, however, may attack a large number of other crops and wild plants. Therefore, it is usually present to some extent in most soils. The fungus is only rarely seed-borne, and infection only infrequently spreads from the seed to the growing plant.

The Sclerotinia fungus may attack any of the parts of the bean plant, causing a rapid soft rot of the tissues under moist warm conditions. A white web of fungus growth usually covers the diseased areas. These areas gradually turn darker in color; the fungus material forms irregularly shaped masses or hard resting bodies that finally turn black. These are called Sclerotia and perpetuate the fungus through unfavorable conditions.

Sclerotia may remain alive in a dry condition for years. When favorable moisture and temperature conditions again occur, a mushroomlike growth forms from the sclerotia and produces spores of the fungus. These spores are spread by wind or rain and under moist conditions may cause widespread development of the disease in the field.

When bean plants become infected with white mold, usually in August, the bean crop is usually starting to mature. The question many farmers must decide is, "Should I irrigate the crop again?" If the crop is irrigated again loss due to the disease may be severe. If the crop is not irrigated there may be loss of yield from small or shriveled seed. If the white mold appears to be spreading with each irrigation it is

Figure 5. Symptoms of Sclerotinia wilt (white mold).

advisable to withhold irrigation water except when the soil is extremely dry.

Rank growth of bean plants, over-irrigation, and flooding of portions of the field provide ideal conditions for the fungus to develop and cause serious loss. Rotation, wide spacing of bean rows, and careful irrigation will tend to minimize losses.

Pythium Wilt is caused by a fungus that attacks the stem of the bean plant at the soil line. A soft slimy rot occurs that extends up into the plant but does not extend much below the soil. In southern Idaho, the fungus usually attacks the plant during the early part of July, and affected plants wilt suddenly without noticeable loss of green color. Although this disease ordinarily is of little importance, it may cause minor damage locally when conditions are favorable for its development. The general recommendations for the control of root rots will also apply in the control of Pythium wilt, although control of this disease is usually considered to be unnecessary in Idaho.

VIRUS

Mosaics. This discussion of bean virus diseases will be limited to curly top and to the three most important mosaics—common bean-mosaic, a severe strain of common bean-mosaic, and yellow bean-mosaic.

Common bean-mosaic and the variant strain of this disease produce symptoms in the field that are impossible to tell apart. A number of varieties of beans are susceptible to the variant but are resistant to the common form. (See the listing of resistant varieties on the introductory page.) These two mosaics are most apparent in the leaves, causing mottling, curling and distortion. Although infected plants may be badly stunted, they are seldom killed.

Yellow bean-mosaic and curly top may cause death of infected plants. As indicated by the name, yellow bean-mosaic causes a yellowing of the leaves, and the contrast between the green and yellow areas of the infected leaves is quite marked. There are a number of strains of yellow bean-mosaic. The one described and illustrated here (Figure 6) is the typical strain common in Idaho.

The viruses of the bean-mosaics are spread in the field by aphids. Common bean-mosaic and its variant is transmitted through infected seed, and the virus remains viable as long as the seed will germinate.

Figure 6. Bean leaves showing symptoms of yellow bean mosaic.

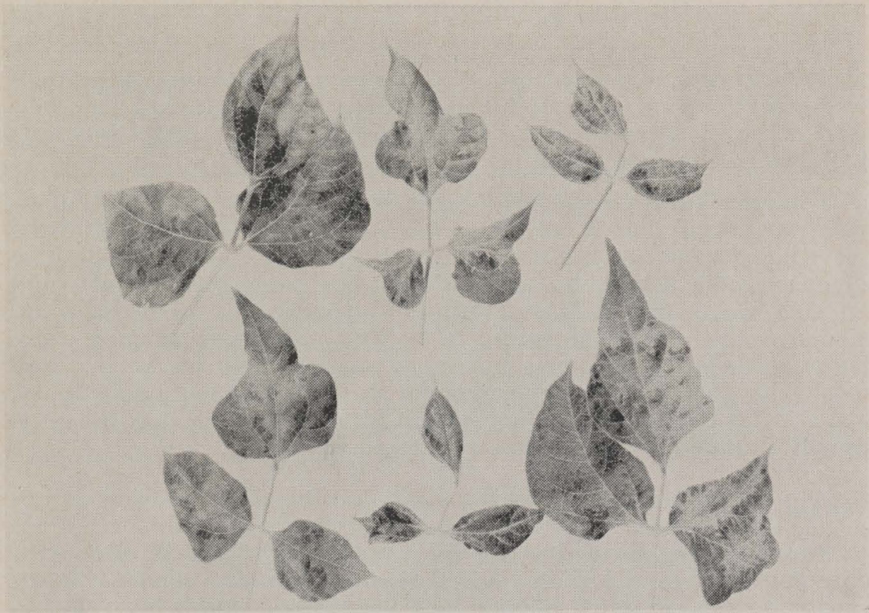


Figure 7. Bean leaves showing variations in symptoms of common bean mosaic.

Figure 8. Curly top virus symptoms on beans. Note downward rolling of apical leaves.

The virus of yellow bean-mosaic does not enter the seed and therefore is not seed transmitted. This disease over-winters primarily in sweet clover plants and is transferred to beans from infected sweet clover by aphids. Although some varieties of beans are more tolerant than others, no variety of dry or snap beans has been found to be resistant to the strain of yellow bean-mosaic common in Idaho.

Curly Top. The virus causing curly top in beans may also infect many other wild hosts and cultivated crops. Few viruses have such an extensive host range. The disease, fortunately, is not seed-borne. It is spread in the field by the beet leafhopper. The amount of curly top infection varies greatly from year to year, depending upon the population of leafhoppers, which in turn is influenced by weather conditions.

Although there are certain symptoms that curly top and the mosaics have in common, it is usually possible to distinguish curly top from the mosaics. When the leafhoppers carry the virus to bean plants early in their growth, the plants turn yellow and die. When infection takes place somewhat later, the leaves may first appear darker than normal in color and later become chlorotic, curl downward, and are considerably thickened and severely rolled downward. Certain strains of yellow bean-mosaic induce somewhat similar symptoms.

The whole plant later presents a dwarfed, yellow appearance, and death often results. Very late infection may result in minor injury to the growing tips of the plant. The most satisfactory control for curly top is to grow varieties of beans resistant to the disease. Fortunately, there are available varieties of Pinto, Great Northern, and Red Mexican beans which are resistant to curly top. Progress is being made with the development of curly top resistant snap beans suitable for processing, and these should be available for seed production soon. It is good insurance to grow resistant varieties if you are located where curly top is a serious disease.

NON-PARASITIC CAUSES

There are numerous disease-like conditions in beans not caused by parasites. Some of these injuries may be of considerable importance when environmental conditions are unfavorable. A detailed description of this group of bean troubles is not possible in this brief discussion but a few of the more important ones will be listed.

When bean seedlings emerge from the ground, some may not have a growing point. These plants have been called **baldheads.** The principal cause for this condition is injury to the growing point of the seed during handling or threshing. This type of injury is not so common in dry beans as in snap beans where it may be of considerable importance in some varieties.

Heat injury lesions may appear in the form of a constriction of the stem close to the soil line when bean plants are exposed to high daytime temperatures. This is especially true in light sandy soil.

Sunscald differs from heat injury in that it will affect all above-ground parts of older plants that are exposed to the direct or reflected rays of the sun. This injury is due to intense sunlight rather than heat. Sunscald on beans is characterized by the appearance of small brown patches between the veins of the leaves, often extending to make larger patches. Partial defoliation or even complete loss of the plant may follow. When there is danger of injury due to sunscald, it is advisable to irrigate bean fields at night, timing the application so that there will not be free water on the soil to reflect the sun's rays.

Alkali injury will appear on bean plants only when the total salts in the soil are relatively high (**Alkali areas.**) The symptoms are yellow, stunted plants that later may actually show some corrosive action of the salts on the leaves. The leaf edges of the affected plants will be brown and dead and often accumulations of the salt may be seen on the leaf surfaces.

Other types of injury include hail damage, fertilizer injury, and injuries caused by an excess or deficiency of essential salts in the soil.

The optimum temperature for bean blossom formation and subsequent fruit set is 85° for daytime and 70° for nighttime. Temperature becomes critical when the daytime high is 97° or above, and it is then that "blossom drop" becomes very evident. Blossom drop in the field is due to a lack of embryo sac development. The reproductive functions of the bean plant are not affected by large variations in the relative humidity and soil moisture during periods of high temperature.

Seed Treatment

Seed treatment of field beans is of doubtful value in Idaho. When beans are planted under unfavorable soil and weather conditions, treatment with some of the newer materials may help to control rotting of the seed or damping-off of the seedlings. Treatment with insecticide-fungicide combinations may be advisable where infestations of wireworms or seed-corn maggot are present.

Insect Pests

Several species of insects and mites attack beans in Idaho and their control must be considered in bean production. The following numbers indicate the areas where these pests are found (northern Idaho 1, southwestern Idaho 2, and southcentral Idaho 3).

MAJOR PESTS

Beet leafhopper, *Circulifer tenellus* (Baker) 1, 2, 3.

Lygus bugs, *Lygus elisus* Van D. 1, 2, 3.
L. hesperus Kngt. 1, 2, 3.
L. desertus Kngt. 1, 2, 3.

Mexican bean beetle, *Epilanchna varivestis* (Muls.) 2, 3.

Red-backed cutworm, *Euxoa ochrogaster* (Guen.) 1, 2, 3.

Seed-corn maggot, *Hylemya platura* (Meig.) 1, 2, 3.

Two-spotted spider mite, *Tetranychus urticae* (Koch) 1, 2, 3.

Western bean cutworm, *Loxagrotis albicosta* (Sm.) 3.

Wireworms, *Limonius californicus* (Mann.) 1, 2, 3.
L. canus (LeC.) 1, 2, 3.
Ctenicera spp. 1, 2, 3.

MINOR PESTS

Thrips, *Thrips tabaci* (Lind.) 1, 2, 3.
Frankliniella spp. 1, 2, 3.

Grasshoppers, *Melanoplus bivittatus* (Say) 1, 2, 3.
M. femur-rubrum (DeG.) 1, 2, 3.
M. sanquinipes (Fab.) 1, 2, 3.

Lima bean pod borer, *Etiella zinckenella* (Treit.) 2.

White grubs, *Polyphylla decimlineata* (Say) 1, 2, 3.
Bothymus gibbosus (DeG.) 1, 2, 3.

Corn earworm, *Heliothis zea* (Boddie) 2, 3.

Cutworms, *Agrotis ipsilon* (Huf.) 2, 3.
Amathes c-nigrum (L.) 2, 3.
Chorizagrotis auxiliaris (Grote) 1, 2, 3.
Peridroma saucia (Hub.) 1, 2, 3.
Pseudaletia unipuncta (Haw.) 2, 3.

When Using Insecticides

1. Select only those insecticides that have Federal clearance for use on beans. Use insecticides that will not contaminate the adjacent crops and that will not be hazardous to pollinating insects visiting the blossoms of the adjacent crop.

2. Follow the insecticide container label directions closely. Apply only the proper amount of the insecticide at a time and in a manner that

will result in thorough coverage of the beans and with the least amount of drift deposit onto the adjacent crop. Only ground applied dust treatments will adequately penetrate the foliage of mature bean plants. Penetration and thorough coverage is necessary for effective insect control.

3. Changes in Federal clearance of insecticides for use on beans may occur at any time. Contact your Extension Agricultural Agent for the latest Federal insecticide registrations.

Major Pests

Beet leafhopper. The beet leafhopper causes damage to beans by transmitting the curly top virus. It spends the winters in vast areas of weeds that have grown up on abandoned farmlands and on burned or overgrazed ranges. In the spring, when these plants mature and dry, the leafhoppers migrate long distances with the wind to summer hosts, transmitting curly top virus to all susceptible plants.

After the leafhopper moves into susceptible crops, there is no entirely satisfactory control. Planting resistant varieties, proper timing of planting dates, and treating roadside and farmyard breeding areas with a spray containing one pound of actual DDT per acre plus a herbicide will aid in reducing curly top damage. Each year the large rangeland concentrations of beet leafhopper are controlled by the Federal-State Cooperative Spray programs.

Lygus bugs. These bugs spend the winter in fencerows, ditch banks, and hay fields. Their feeding may kill young bean plants or the terminal portion of older plants. Blossom-drop and small malformed pods are the result of lygus attacking the petioles. When attacking large pods with filling beans, they force their beaks through the pods into the individual beans, causing them to become deformed and "cat-faced," which reduces the market value.

Lygus bugs are readily controlled with 1½ pounds of actual DDT or tri-chlorfon per acre. In the southwestern and southcentral Idaho areas where the two-spotted spider mite is also a problem, the use of 5 percent DDT plus 50 percent dusting sulfur at the rate of 30 pounds per acre will control both pests.

Mexican bean beetle. Based on the extensive damage and the cost of control of the Mexican bean beetle in other areas, this insect is a constant threat to Idaho's bean industry. In Idaho this pest occurs only in a few fields in the immediate vicinity of Rupert and in a small area within the city limits of Boise. Efforts are under way to eradicate these infestations.

The adult is $\frac{1}{3}$ inch in length, ovate in outline and of a yellow to coppery-brown color with 16 black spots arranged in three rows across the body. The larva is oval, yellow in color and has six rows of long branching black-tipped spines on its body. Anyone seeing insects having these characteristics should have the specimens immediately identified by their Extension Agricultural Agent or other authority.

The feeding damage of the adults and larvae is characterized by the skeletonizing of the undersurfaces of the bean leaves. Pods may also be attacked. Following the attack of the insects, plants dry rapidly and may be killed within a month. Under Idaho's situation eradication efforts include burning the infested plants and also those immediately adjacent without removing them from the area of infestation. A malathion spray will kill all the Mexican bean beetles and larvae that are contacted by the insecticide.

For additional information see University of Idaho Extension Bulletin 433, the Mexican Bean Beetle.

Red-backed cutworm. This cutworm feeds on a variety of broad-leaved plants, including beans. The moth deposits her eggs in mid-to late-summer. Those eggs hatch the next spring, and in about 45 days the cutworms have completed their development.

They are readily controlled by an application of 3 pounds of actual toxaphene or 1½ pounds of actual trichlorfon per acre. Where the ground has "crusted" and the cutworms are feeding beneath the surface, the field should be irrigated to bring the worms above ground before applying the insecticide.

Seed-corn maggot. When bean seeds are planted in soil with abundant organic matter, the seed-corn maggot may seriously reduce the stand during springs characterized by cold, wet, slow-growing weather. In the spring the overwintering adults deposit their eggs in the soil. The tiny yellowish-white larvae burrow into the developing seeds and young plant stems, weakening or killing them, however, the spring generation is responsible for the major damage. There are several generations each year.

Shallow planting in warm, well-prepared seedbeds is recommended. Seed treatments of 1 ounce of actual dieldrin or lindane plus a fungicide per 100 pounds of seed are effective.

Two-spotted spider mite. In southern Idaho, beans grown adjacent to alfalfa and clover fields are generally the most heavily infested. Mite feeding injury appears first as pale yellow to reddish-brown spots on the under-surface of the leaves. Later both surfaces of the entire leaf are damaged. The mites prefer the under leaf surface where they spin a fine silken web. This webbing protects the eggs, nymphs and adults of the mite colony. There are many generations each year.

Potential infestation from harvested hay fields adjacent to bean fields can be reduced by applying 25 pounds of dusting sulfur per acre in a 20- to 30-foot border around the field. Later, when the first mite injury appears on the beans the entire field should be treated with dusting sulfur. Carbophenothion and ethion are also effective.

Western bean cutworm. This insect is a problem in southcentral

Idaho where beans are grown on light, sandy soils. Unlike other cutworms, this species is not cannibalistic and is primarily a pest of beans but will attack corn and tomatoes. The adults mature in over-wintering larval cells in the ground and emerge the latter part of July. The larvae are first found during the first week in August. As high as 25 percent injury has been noted in harvested beans. The larvae eat through the pod and into the developing bean. Occasionally a larva may tunnel through the pod, destroying all the beans in that pod.

Treat the entire field immediately upon finding the tiny larvae, and before they commence to feed on the pods or beans. Apply 5 percent DDT dust at the rate of 20 to 25 pounds by ground, or 25 to 30 pounds by air per acre. The seed never recovers once it's been fed upon. Control must be properly timed and thoroughly applied for good results. Usually applications should be made during the first ten days of August. Every care should be taken to prevent drift deposits on adjacent cropland.

Wireworms. When the soil is infested, bean stands will be severely damaged and many times will require replanting. See University of Idaho, Current Information Series Number 42, Wireworm Control. Soil treatment, which consists of thoroughly mixing ten pounds of actual DDT in the top six to eight inches of soil, will kill the wireworms and prevent them from reinfesting the soil for about eight years. This should be done a year prior to planting beans since DDT may not give effective control the first year the soil is treated when there is a large wireworm infestation.

Prevent illegal residues from occurring on sugar beets when they are planted in rotation with beans by allowing at least two growing seasons between treating the soil with DDT for wireworm control and the planting of sugar beets.

Minor Pests

With the drying of native weed hosts, the maturing of grain and peas and the cutting of hay crops, **thrips** are forced to move from these crops and often infest beans. The infestations vary from season to season and from field to field. Thrips often move into bean fields in large numbers but since beans are not a preferred host, very few remain throughout the growing season. Therefore, their injury to beans is of minor importance. They feed on the blossoms and on the underside of the leaves by rasping and puncturing the cells of the plant surface, causing a "silvering" of a portion of the lower surface. Severely injured lower leaves become dry prematurely. Inadequate irrigation will also result in premature leaf drop. By keeping the plants slightly on the wet side, the leaves will not dry and fall off. Thrips are very difficult to control. They are protected by the dense leaf cover. Several insecticides are effective in killing thrips but the cost of control on beans is seldom justified and is often ineffective.

When **grasshoppers** are migrating into beans, the adjacent field margin can be treated with malathion sprays. This may stop migration and save the expense of treating the entire field.

White grubs are usually found in soil recently taken out of sod. Wireworm control, as listed above, is also effective for white grub control.

Every five to seven years, **corn earworms** are a problem in beans, About one week after the moths are seen in the field the tiny larvae will be found. Effective control may be obtained by applying DDT. Application should be made just as soon as the first larvae are found.

On rare occasions the **lima bean pod borer** causes some damage in southwestern Idaho. The infestations are generally light as the natural enemies of the pod borer hold it in check.

In the spring several species of **cutworms** may occasionally be found cutting off the newly emerged bean plants. Toxaphene, other chlorinated hydrocarbon insecticides and trichlorfon are very effective in controlling these migrating pests.

Should an unfamiliar pest become a problem, contact your Extension Agricultural Agent for assistance.

Pesticide Residues

These recommendations are based on the best information currently available for each chemical listed. If followed carefully, residues should not exceed the tolerance established for any particular chemical. To avoid excessive residues, follow recommendations carefully with respect to dosage levels, number of applications and minimum interval between application and harvest.

The **GROWER IS RESPONSIBLE FOR** residues on his crops as well as for problems caused by drift from his property to other properties or crops.

TIMES-NEWS COM. PTG. DEPT.

Other University of Idaho Publications That May Be of Interest to Bean Producers

A New Pinto Bean Resistant to Mosaic and Curly Top (UI-114), Exp. Sta. Bul. 485.

A New Snap Bean Resistant to Mosaic and Curly Top, Exp. Sta. Bul. 442.

Halo Blight, Extension Bul. 444.

Idachief and Idagem Curly Top and Mosaic Resistant Snap Bean, Exp. Sta. Bul. 499.

Influence of Soil Moisture on Snap Bean Seed Production, Exp. Sta. Bul. 435.

Irrigation of Field Beans in Idaho, Research Bul. 37.

Mexican Bean Beetle in Idaho and the West, Extension Bul. 443.

Red Mexican Beans UI-36 and **UI-37,** Exp. Sta. Bul. 429.

Spring and Fall Freezing Temperatures in Idaho, Exp. Sta. Bul. 494.

Study of Simulated Hail Injury in Beans, Exp. Sta. Bul. 322.

Copies of these and other University of Idaho agricultural publications may be secured from county agricultural agents or by writing to the Director, Idaho Agricultural Extension Service, Moscow (83843) or Boise (83701).