Farmer's Bulletin 1735

PEA Diseases

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CONTENTS

This handbook contains information of the type formerly carried in Farmers' Bulletin No. 1735, Pea Diseases and Their Control.

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PEA DISEASES

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Peas are subject to a number of diseases, several of which may cause serious injury or loss. Annual losses from diseases vary from year to year, depending often on local weather conditions. If the soil is wet from excessive rains and the weather is cool, heavy losses may be expected from root rots and from such diseases as ascochyta and bacterial blights. If the soil is badly infested with root-rotting organisms, total loss may result. This bulletin describes the diseases briefly, gives their causes, outlines known methods for their prevention, and makes recommendations for their control.

THE PEA INDUSTRY

Peas are important in the diet of a large percentage of the population of the United States. They are grown to some extent in almost every part of the country—for home use, for canning, for freezing, for seed, and for market.

The processing of green peas for canning and for freezing is a very important industry in a number of States. About 335,000 acres were grown for this purpose in the United States in 1960. The States growing the largest acreages were Wisconsin, Washington, Oregon, Minnesota, Illinois, Idaho, and New York. Other States with smaller acreages were California, Maryland, Delaware, Michigan, and Pennsylvania.

The seed-growing phase of the industry is highly specialized and is centered chiefly in Washington and Idaho. States growing smaller acreages of field peas for this purpose are Oregon, North Dakota, Colorado, and Minnesota. The total acreage grown for seed in the United States in 1960 was about 285,000 acres. Seed and field-pea production often overlap, because peas grown for seed but not sold for this purpose may be sold as dry field peas.

A comparatively small number of commercial companies produce most of the seed, although a considerable number of farmers grow the seed for them. Many of the dry field peas are used for split-pea soup, and as seed for forage, green-manure, and cover crops.

Over 100,000 acres of green peas were grown for fresh market in the United States 20 years ago, but at present this industry is of minor importance. In 1960 about 6,000 acres were grown for this purpose, with California growing 75 percent. Other States growing small acreages were New York and Colorado.

HOW PEA DISEASES ARE DISSEMINATED

The fungi and bacteria causing diseases of peas may be carried from one place or plant to another by insects, infected seed, drainage water, refuse and stable manure, farm animals and implements, and wind.

Insects

There is no way to determine to what extent insects carry diseases from one plant to another. Insects such as aphids or plant lice, thrips, and leafhoppers are common inhabitants of plants and migrate frequently from one to another. Wounds made by insects feeding on the plant offer favorable places for infection. Insects visiting the lesions caused by fungi and bacteria may carry the germs on their bodies and deposit them on noninfected plants and perhaps in the wounds made by the insects; in this way, if conditions are favorable, they start new infection centers.

Virus diseases such as the various pea mosaics and streak are transmitted by aphids from infected plants to healthy ones or from infected legumes such as clovers to peas.

Infected Seed

Some disease-producing fungi and bacteria are carried by the pea seed. If infected seed is planted, heavy losses may be expected if weather conditions are favorable to the development of the disease-producing organisms. If clean seed is planted, a crop can usually be grown without much loss from diseases that are commonly seedborne.

Drainage Water

Surface drainage water running from one field to another may spread disease germs to a field where peas have not been grown before. If seed is planted on high ground, germs left in the soil may be carried by the water to low-lying fields. In rotating their crops to control diseases, growers may plant their seed in a low-lying field only to find the disease already present in the soil.

Refuse and Stable Manure

Disposing of pea vines after the peas are shelled depends considerably on local conditions and farm needs. In some localities the vines are returned to the soil after the peas are hulled. In other localities they are stacked and used as feed and bedding for livestock. In still other localities the vines are made into silage to be fed later to livestock.

If diseased vines are returned directly to the soil, the causal organisms will probably infect the next crop of peas. Just what happens to the disease germs on vines put into the silo is not definitely known. They are probably destroyed, and, if so, the vines made into silage will not infect succeeding crops. On the other hand, returning those vines to the field, using them for feed, or mixing them with stable manure may spread the germs to all parts of the farm where the mixture is scattered.

In irrigated sections of the West where peas are grown commercially, the threshed vines are sometimes used to dam irrigation ditches to divert the flow of water into other ditches or to the fields. This practice should be avoided, because any disease-producing organisms on the vines will be carried by the water to all parts of the fields.

Farm Animals and Implements

Farm animals are potential agents for distributing disease germs from one field to another. Some livestock movement is unavoidable in farm operations, but it should be limited when there has been serious loss from diseases. Horses, cattle, or other livestock feeding on diseased refuse after the crop is harvested are likely to scatter the disease-producing organisms. Farm implements may likewise transport germs from one place to another, but thorough cleaning of the implements eliminates the danger of spreading diseases in this way. Reasonable care should be taken to keep infested soil from being carried from one field to another by roaming animals or by farm machinery.

Wind

The wind may be an important factor in disseminating certain pea diseases. In localities where strong winds are prevalent, dry weather is common, and soil is light, the spores of disease-producing organisms may be carried long distances. The refuse from a diseased crop may also be blown some distance by strong winds.

CONTROL PRACTICES

Using Resistant Varieties

The most satisfactory way of controlling pea diseases is to grow known resistant varieties. The use of such varieties is about the only way to control diseases caused by organisms that live almost indefinitely in the soil and are slightly or not at all influenced by crop rotation and deep plowing. In the discussions of individual pea diseases that follow, varieties known to be resistant are listed.

Using Disease-Free Seed

Because some of the most serious pea diseases are carried by seed, it is important to use disease-free seed whenever possible. Some seedborne diseases do not develop in regions that have low rainfall and high temperatures during the growing season. Pea seed grown in the semiarid intermountain area of the West and along the Pacific coast is more nearly free from seedborne diseases than seed grown in the East. For this reason, only seed from the western area should be planted.

To economize, growers sometimes save seed from their own crops to plant the following year. This practice is not recommended because, if the seed is infected, heavy crop losses may result. Seed growing is an industry requiring particular knowledge of the type and quality of the varieties grown. Special care is needed to maintain the purity and trueness to type of the stock. Seed-growing

companies employ experts to improve and maintain the high quality of their stock. The purchase of disease-free seed from reputable firms is recommended.

Seed Treatment

Disinfecting pea seed with chemicals helps to prevent stand failures caused by seed decay and increases the vigor and productivity of plants. However, disinfecting destroys only surface germs; those beneath the seedcoat cannot be reached without injuring the seed itself.

Applications of chloranil (sold as Spergon), thiram (sold as Arasan), dichlone (sold as Phygon),[1] and captan at the rate of 1½ to 2 ounces per bushel have proved beneficial in preventing decay of seed planted in cool, wet soils. Addition of 1 ounce of graphite to any of these except chloranil is recommended as a lubricant. Most treatments are now applied as a slurry, and many contain a dye that colors the seeds orange, red, green, or black.

CAUTION

The chemicals mentioned are injurious in varying degrees to man and animals when taken internally; therefore, care should be taken in handling them. When large quantities of seeds are treated, a dust mask should be worn, but this is not necessary when small quantities of seeds are treated outdoors or in a well-ventilated room. Poisonous powders and tablets should be kept in a safe place out of reach of children.

Crop Rotation

The germs of several pea diseases live 2 or 3 years in the soil on the debris of previous crops; the germs of others live much longer. If peas are repeatedly grown on the same soil, the disease-producing germs may continue to multiply year after year. Lack of information on the time required to starve out all the disease organisms attacking peas makes specific recommendations for control impossible. However, a crop rotation including peas planted not oftener than once in 3 years is good practice. Where farm operations and practices permit, a longer rotation is desirable. No vetch should be grown in a pea rotation, because some of the same diseases attack both crops.

The life of some of the germs is shortened if they are buried deep in the soil. Because of this, the refuse remaining on the field and the vines returned to it after threshing or hulling should be plowed under immediately after harvest.

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[1] The mention of proprietary products does not imply their endorsement by the U.S. Department of Agriculture over similar products not named.

DISEASES

Ascochyta Blight

Description

Ascochyta blight is characterized in part by the formation of black to purplish streaks on the stem. The lesions are more conspicuous at the nodes and enlarge into brown or purplish irregularly shaped areas scattered indiscriminately from the roots to 10 inches or more up the stem.

The leaves may show various characteristic symptoms (figs. 1 and 2) of the disease. The spots may be very small, purplish, and very irregular in shape and size, or they may be fairly large and more or less circular. The size and number of spots and the amount of damage caused depend somewhat on the age of the plants and on weather conditions. Under favorable conditions, the entire leaf of a very susceptible variety may be so badly injured that it shrivels and dries up. Concentric circles sometimes form in the spots on the leaves. Some of the lesions have ashen-gray centers.

The symptoms on the pods (fig. 1) are similar to those on the leaves, except that the spots on the pods are sunken and have no concentric circles. The causal organism frequently grows through the pods and penetrates the seed. If such seed is used to plant the next year's crop, it serves as a source of infection. A few small, black or almost black, slightly raised, pimplelike protuberances about the size of a pinpoint may be found scattered in the lesions of the stems, leaves,

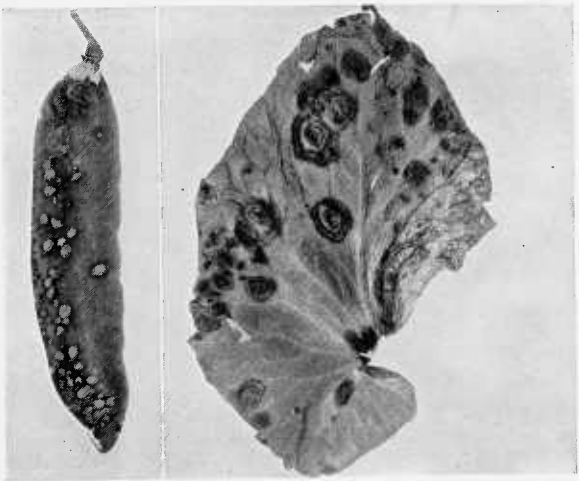

FIGURE 1.—Ascochyta blight on a pea pod and a leaf. Small, dark fruiting bodies about the size of a pinpoint occur in the more or less circular spots. The spores are enclosed in these receptacles and, on escaping, may fall on other plants and serve as sources of new infections.

FIGURE 2.—Ascochyta blight on a pea plant. Note the small, purplish (dark) spots about the size of a pinhead. (Courtesy, Wisconsin Agricultural Experiment Station.)

and pods. The spores of the casual fungus are produced in these little pimples.

When infected seed is planted, the infection of the seedling may be noted at the point where the seed is attached to the stem. A foot or root rot may extend up the stem and down to the taproot. The larger roots may also become infected. Sometimes a stem lesion becomes an important source of spread of the fungus.

Cause

Ascochyta blight is caused by any of the three parasitic fungi—*Ascochyta pisi* Lib., *A. pinodella* L. K. Jones, and *Mycospharella pinodes* (Berk. & Blox.) Vest. Although the symptoms produced by the three fungi may differ somewhat, they have so many characteristics in common that it seems desirable to treat the diseases as one rather than to differentiate them by fine points of distinction. Ascochyta blight occurs in all States east of the Mississippi River, but it is not nearly so common in the semiarid seed-producing sections of the West. It may cause heavy losses during seasons of abundant rainfall. The causal organisms are carried by the seed and infect the seedlings when they emerge. Rains after germination splash the spores to surrounding plants, and eventually many of the plants in a field may become infected.

Control

The fungi causing ascochyta blight are seedborne. They may also live from one season to the next on refuse in the field. New infections may start from this refuse and from use of infected seed. To control this disease, only clean seed should be planted. As stated earlier, western-grown seed should be used if possible. Crop refuse in the field should be plowed under deep as soon as the crop is harvested. At least a 3-year crop rotation should be practiced, and diseased pea vines should not be scattered on land to be used for the next year's crop.

Treating infected seed with chemicals is of no value in controlling the disease.

No varieties of peas have been found that are highly tolerant to ascochyta blight. Complete control of this disease is probably not possible until definitely resistant varieties have been developed by breeding and selection.

Bacterial Blight

Description

Bacterial blight of peas is found on all parts of the plant above the ground. If the infection starts from the seed or if the plants are not more than 3 inches high, the vines may die without producing a crop. Infection established later may reduce the yield considerably. The extent of the injury depends largely on weather conditions.

Bacterial blight causes water-soaked lesions on the pods (fig. 3, *A*), stems, leaves (fig. 3, *B*), and stipules. These lesions enlarge under humid conditions, and sometimes spots of considerable size appear. A white to cream-colored, slimy ooze may also collect on the surface of the lesions. On the other hand, if the weather turns dry, the infection may dry up. The infected tissue of the leaves and stipules eventually turns brown and becomes papery in texture.

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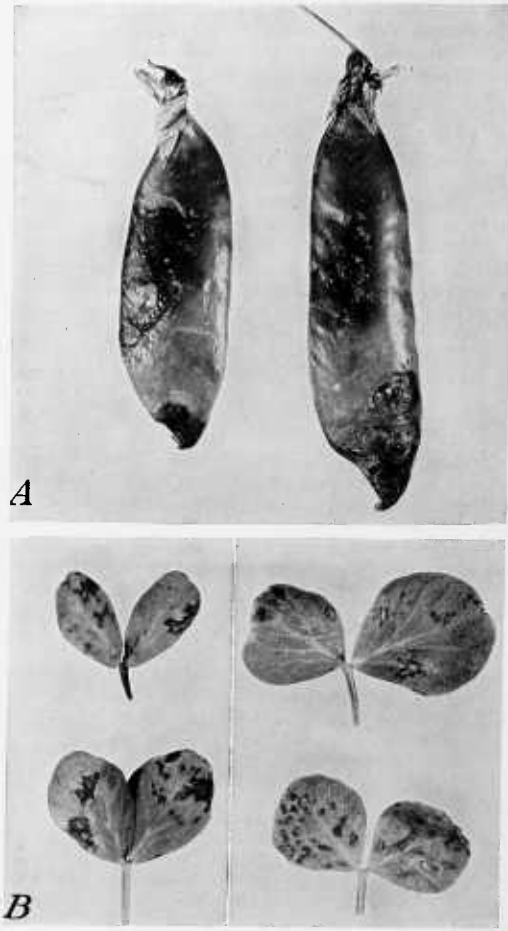

FIGURE 3.—*A*, Bacterial blight on pea pods. The water-soaked, irregularly shaped spots are slightly sunken. The seed may be invaded by the parasite and serve as a source of infection for the new crop. Such seed should not be planted. *B*, Bacterial blight on pea leaves. These spots start as small, water-soaked areas which gradually kill part of the leaf. Sometimes the injury is so extensive that the plant dies.

Extensive infection of the pods reduces their market value considerably because of their unsightly appearance. The germs may spread through the pods and infect the seed. Thus, the infection would be transmitted to a new crop if the infected seed were later planted.

Bacterial blight has been reported from many States but is more commonly found east of the Continental Divide than west of it. The extent of loss from the disease is not known, but at times the estimated damage has been 25 to 30 percent or more in some fields. In recent years, losses this great have not been reported. The disease is most severe when humidity is high.

Cause

Bacterial blight is caused by a parasite (*Pseudomonas pisi* Sackett) that lives over winter in the seed. It is not known if the parasite lives on the refuse left in the field from harvesting. If the germs do not survive the winters in the field, the seed is practically the only source of infection.

Control

No effective control measures are known. Clean seed offers the best possibility of avoiding infection. Although the disease has been reported from several Western States, it is of minor importance and is seldom observed in those States where pea seed is produced, as in southern Idaho and central Washington, and in the Palouse area, which comprises parts of eastern Washington and northern Idaho. Growers of peas for processing and market-garden purposes should request seedsmen to supply seed grown in these areas.

No permanent control under all conditions can be expected until varieties resistant to the disease are developed by breeding and selection.

Fusarium Wilt

Description

When fusarium wilt first appears in a field, only a few plants show any signs of disease. If susceptible varieties are planted several years in succession on the same field, the infested areas (fig. 4) gradually enlarge, become more numerous, and eventually merge with others. Finally, all the soil in the field may be infested.

Attention is first attracted to wilt by the yellowing of the lower leaves and the stunted growth of the plant. A more careful examination shows a definite downward curling of the margins of the leaves (fig. 5). If infection occurs when the plants are fairly small, they may die without producing any peas. If the plants are older when infected, a few poorly filled pods may develop. At or near the soil level, the stem is sometimes slightly swollen.

Infection takes place from the soil through the roots. The causal organism follows the water-conducting canals up the stem, often well into the upper branches, and thus hinders the passage of water to the stem and leaves. If the lower part of the stem or the main root is cut open, a lemon to orange-brown discoloration of the canals may be seen. Sometimes, however, no discoloration is produced even

FIGURE 4.—Part of a peafield infested with fusarium wilt.

though the wilt organism is present. These symptoms must not be confused with the much brighter brick-red discoloration of the water canals characteristic of near-wilt. If wilt-infected plants are pulled and examined several days after injury is apparent, root-rotting or other disease-producing germs in the soil may have so damaged the roots that it is almost impossible to determine what organism was responsible for the injury.

Cause

Fusarium wilt of peas is caused by a fungus parasite (*Fusarium oxysporum* Schlecht. f. *pisi* (Linf.) race 1 Snyd. & Hans.) that is very similar to organisms causing wilt in a number of other cultivated plants, including tomato, sweetpotato, cotton, cowpea, watermelon, and cabbage.

Control

Fusarium pea wilt can be controlled only by growing resistant varieties, because the parasite lives indefinitely in the soil and cannot be destroyed by crop rotation. A large number of resistant strains, especially of the canning and freezing varieties, are now on the market. Resistant strains of the choice market-garden varieties are also available.

Table 1 contains a list of common varieties of peas and shows if they are resistant or susceptible to fusarium wilt. Resistant varieties should be selected for planting on soils that are known to be infested with the wilt organism. Investigations have shown that strains of peas that are resistant to the wilt organism in one infested locality are resistant to it in other infested localities, no matter how distant. Not all infected plants are killed before they produce seed; infected plants that survive usually mature earlier than do noninfected ones and pass the canning stage before the bulk of the crop is ready to harvest. These prematurely ripened peas reduce the quality of the pack.

FIGURE 5.—Fusarium wilt on a pea plant. Note the wilting and drying of the lower leaves and the downward curling of the upper ones.

TABLE 1.—*Reaction of common varieties of peas to fusarium wilt*

Commercial use, season, and variety	Reaction to fusarium wilt
Market-garden varieties:	
Early:	
Alaska [1] (numerous strains).	Resistant.
Hundredfold	Susceptible.
Laxton Progress	Do.
Laxton Superb	Do.
Little Marvel	Resistant and susceptible strains.
Progress No. 9	Resistant
Thomas Laxton [2]	Resistant and susceptible strains.
World Record	Resistant.
Midseason:	
Alderman [2]	Do.
Giant Stride (No. 40, Icer No. 95).	Do.
Morse Market	Do.
Rondo	Susceptible.
Canning varieties:	
Early:	
Alaska (numerous strains).	Resistant.
Alsweet No. 4683	Do.
Early Harvest	Do.
Early Sweet	Do.
Early Sweet No. 11	Do.
Laurel	Do.
Lolo	Do.
Pixie	Do.
Surpass	Do.
Surprise	Resistant and susceptible strains.
Winner	Susceptible.
Wisconsin Early Sweet.	Resistant.
Yukon	Do.
Midseason:	
Ace	Do.
Bridger	Do.
Cascade	Do.
Early Perfection	Resistant and susceptible strains.
Eureka	Resistant.
Canning varieties—Con.	
Midseason—Con.	
Famous	Resistant.
Hardy	Do.
Midway	Do.
New Era	Do.
Nome	Do.
Perfected Wales	Do.
Perfection (numerous strains).	Do.
Pride	Do.
Profusion	Do.
Ranger	Do.
Shoshone	Do.
Signal	Do.
Small Late Canner	Do.
Wasatch	Do.
Wisconsin Perfection.	Do.
Freezing varieties:	
Early:	
Early Freezer	Do.
Freezonian	Do.
Freezer 37	Do.
Frosty	Do.
Glacier	Do.
Jade	Do.
Laxton 7	Do.
Thomas Laxton	Resistant and susceptible strains.
Midseason:	
Alderman	Resistant.
Dark Skin Perfection.	Do.
Freezer 626	Do.
Freezer 640	Do.
Hyalite	Do.
Midfreezer	Do.
Oracle	Do.
Perfected Freezer	Do.
Pluperfect [1]	Susceptible.
Small Sieve Freezer.	Resistant.
Victory Freezer	Do.
Viking	Do.
Edible podded varieties:	
Dwarf Gray Sugar.	Do.
Mammoth Melting Sugar.	Do.

[1] Also used as a canning variety.
[2] Also used as a freezing variety.

Near-Wilt

Description

In the past 20 years a disease of peas called near-wilt, which has much in common with wilt, has been observed. The leaflets of infected plants curve downward and become pale yellow green, and the growth of the plant is stunted. The stem near the ground becomes swollen and brittle, the leaves wither, and the plant eventually dies. The near-wilt organism may attack the plant at a later stage of growth, sometimes after the crop is nearly mature. For this reason the loss from near-wilt is much less than that from wilt, because the wilt fungus usually enters the roots of very small plants and kills them while they are fairly young. Near-wilt may be readily overlooked; and the sickly appearance of the plants may be attributed to root rots, lack of soil fertility, or other causes.

Near-wilt has early symptoms similar to those of wilt, but with these differences: (1) The water-conducting vessels become brick red instead of orange brown, and the discoloration runs up the entire plant; (2) near-wilt is usually not found in circular spots in the field; only scattered plants may be affected; (3) near-wilt develops more slowly and when temperatures are higher.

Near-wilt differs from root rots and may be distinguished from them by at least two characteristics. Plants affected with root rots usually pull from the soil much more easily than do near-wilt- or wilt-infected plants. Near-wilt-infected plants may not show any signs of root decay, whereas plants affected with root rots do.

Cause

Near-wilt is caused by a fungus (*Fusarium oxysporum* Schlecht. f. *pisi* (Snyd.) race 2 Snyd. & Hans.) closely related to that of fusarium wilt that enters the water canals of the taproot and stem, just as does the wilt fungus.

Control

When near-wilt was first discovered, it was found to affect all wilt-resistant and wilt-susceptible varieties, although it develops more slowly in some than in others. The only control measure is the use of the disease-resistant varieties Commando, New Era, New Season, New Wales, and New Pride. These varieties have not been generally accepted by canners, but they are used primarily as breeding lines.

Root Rots

Description

Root rots are caused by several different parasites that produce symptoms so much alike that it is not always easy to distinguish them by a casual examination.

Root rots, as the name indicates, occur on the roots or on all the underground parts of the plants and sometimes extend a short distance above the surface of the soil. Most of the lesions are grayish brown or almost black, but occasionally some are reddish; and definite streaks form on the taproot or on the stem near the soil line. Root rot may begin when the plant is in the seedling stage, or before it comes through the ground. Death of the plant soon follows such

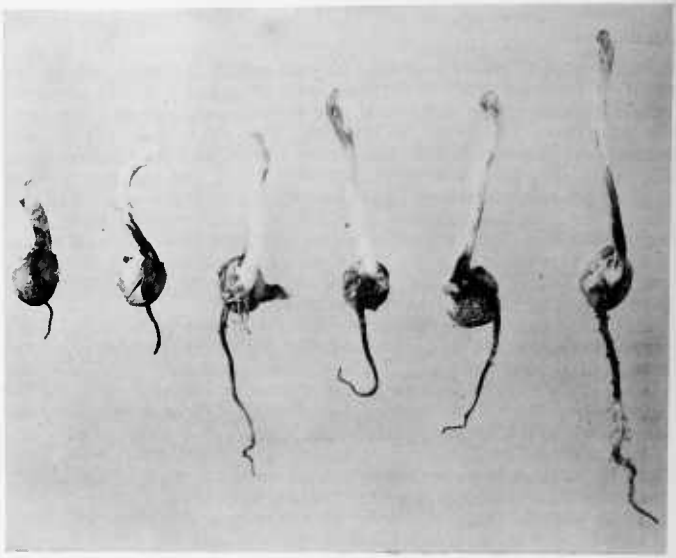

FIGURE 6.—Root rot on pea seedlings, which may be caused by several different organisms.

early infections. Root decay often begins at the tips of the small feeding roots and progresses gradually upward to the main root. In some instances, all the roots are destroyed, leaving nothing, or only shreds, below the attachment of the seed (fig. 6). Sometimes, however, the main root is the first to be affected. Root rots cause severe crop losses.

In the root rot caused by the parasite *Aphanomyces euteiches* Drechs., the initial infection takes place either through the small feeding roots or directly on the taproot. The final result is that the surface becomes soft and slimy and dark gray or brownish black. The slimy condition of the surface is greater in wet than in dry soils. In typical examples of root rot caused by this parasite, the outer portion of the taproot can be slipped readily from the central cylinder, which may often become somewhat water-soaked and soft. The decay may extend a short distance above the surface of the soil.

The root rot just described should not be confused with another very widespread root rot caused by the parasite *Fusarium solani* (Mart.) Appel & Wr. f. *pisi* (F. R. Jones) Snyd. & Hans. This fungus usually attacks the lower part of the stem where the seed is attached (fig. 7) and grows in both directions but more conspicuously up the stem. The infected region turns dark brown to brick red. The same parasite may be found on the feeding roots, but it is less common there than on the main root. This root rot may be identified with more certainty by the deep-red discoloration of the central cylinder. By splitting open the stem where the seed is attached, or just above, the red color-

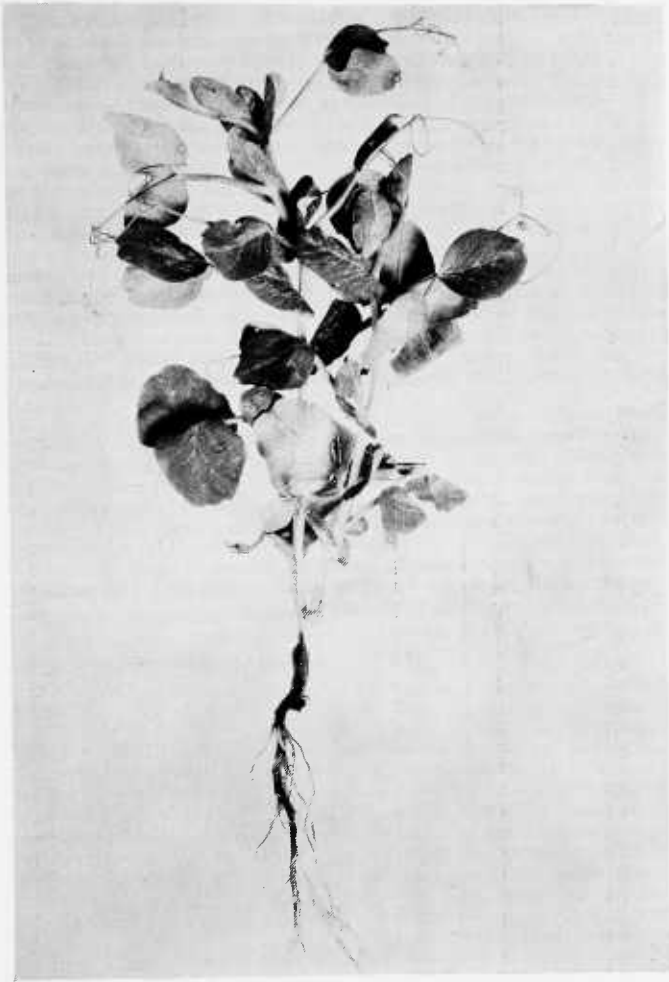

FIGURE 7.—Root rot on a pea plant. Note the typical darkened area above and below the point of attachment to the seed.

ing caused by the presence of the fungus may be seen to extend a little distance upward.

It is not possible to describe symptoms of other root rots in sufficient detail to distinguish them from root diseases caused by other parasites. In advanced stages, the symptoms for all are very much alike. The root diseases of a single plant are not always caused by just one parasite; several parasites may damage the roots at the same time.

No particular skill is required to recognize root rots. Observant farmers can recognize them if they examine the roots. It makes little difference what organism or group of organisms cause them. Even skilled observers are frequently unable to identify the causal organism without laboratory study. If the plants in the field are stunted or the leaves are pale yellow or appear unhealthy in other ways, it is a good plan to dig up some of the plants, carefully wash off the soil, and examine the roots for decay.

Root rots occur wherever peas are grown, although the loss in one field may sometimes be small. Taking the country as a whole, more loss is believed to be caused by root rots than by any other single disease and possibly more than by all other diseases combined. Root rots and wilt frequently occur together in the same fields. When this happens, it is difficult to determine which causes the greater loss.

Cause

Several organisms are known to cause root rots, and others may be responsible. The fungi generally associated with root decay are: *Fusarium solani* f. *pisi*, *Aphanomyces euteiches*, *Rhizoctonia solani* Kuehn, *Pythium ultimum* Trow, *Ascochyta pinodella*, *Mycosphaerella pinodes*, *Sclerotinia sclerotiorum* (Lib.) DBy., *Thielaviopsis basicola* (Berk. and Br.) Ferr., and *Sclerotium rolfsii* Sacc. The last-named organism is restricted mostly to the Southern States. Several of these organisms cause root rot of crops other than peas, and probably all of them can live indefinitely in the soil.

Control

The root rots of peas, like those of many other crops, are hard to control. Because they are caused by organisms that live indefinitely in the soil, there is no practical way to eradicate them. Control measures for all root rots are about the same.

Root rots are usually more severe during seasons of heavy rainfall than during dry seasons and on low-lying fields that are poorly drained than on well-drained fields. Excessive soil moisture, regardless of the location of the field, favors root rots. Where root rots have been troublesome, it is advisable to select well-drained fields and to prepare the soil thoroughly before planting. Plants that start growth poorly, as they do on impoverished soils, are much more subject to attack of root rots than are plants grown on rich soils where a good, vigorous growth is maintained from the beginning. Thus a fertilizer should be added to the soil where needed.

Crop rotation is recommended as a good practice, but it is of no particular value in controlling pea diseases except in the case of those organisms that attack only peas. However, most of the fungi are about as parasitic on other crops that might be grown in rotation as they are on peas.

At least a fair crop often can be grown in spite of root rots.

Root Knot

Description

Root knot, which occurs throughout the United States but is most severe in the light, sandy soils of the South and in similar districts in California, is characterized by enlarged, irregularly shaped, deformed, fleshy galls (fig. 8) distributed on the root system. If the galls are broken open, pearl-white bodies about the size of a pinhead may often be seen. These are the female worms that cause the galls.

The root knot galls may sometimes be confused with the nodules that normally develop on the roots of garden and field peas, beans, and other legumes; but they are quite different. The nodules are usually smaller than the root knot galls, they are more nearly round, and they are attached somewhat loosely to the roots; whereas the root knot galls are enlargements of the roots themselves. Plants bearing nodules generally grow well and look healthy; whereas those with root knot are usually stunted, yellow, and sickly looking and may even be killed by the disease.

Cause

Root knot is caused by parasitic nematodes, or eelworms, of several species of the genus Meloidogyne. These nematodes are so small they are almost invisible to the unaided eye. They enter the roots and cause them to form irregular swellings, or galls. These galls retard the growth, reduce the yield, and often kill the plants. To a considerable extent, they cut off the transport of food material from the roots to the rest of the plant. The nematodes travel very slowly in the soil, probably not more than 1 or 2 yards a year; and they overwinter in the soil.

Control

The root knot nematodes are parasitic on a large number of cultivated plants and on many weeds. However, the various species or kinds of nematodes differ from one another regarding the plants on which they develop. A number of crops are immune from many of the species, or at least highly resistant to them. Iron and Brabham cowpeas, Laredo soybean, peanuts, velvetbeans, barley, rye, redtop, sorghum, timothy, wheat, and winter oats show varying degrees of resistance to most species.

The most satisfactory method of controlling the disease is to practice rotation with immune crops for 3 or more years to starve out the nematodes. Clean cultivation should be practiced to prevent the growth of susceptible weeds on which nematodes feed. Growers should guard against carrying nematodes from one field to another in tubers, bulbs, or roots of growing plants; on implements; in drainage water; by roaming farm animals; or by other means.

Septoria Blight

Septoria blight, caused by a fungus parasite (*Septoria pisi* West.), is one of the minor diseases of peas. It occurs mostly in the Northern States during cool, wet weather. Septoria blight is sometimes confused with ascochyta blight; but, when the two diseases are carefully compared, they are easily distinguished. The spots caused by *Sep-*

FIGURE 8.—Root knot of pea plants, caused by a small parasitic nematode, or eelworm, that invades the roots. The galls may form at any place on the roots.

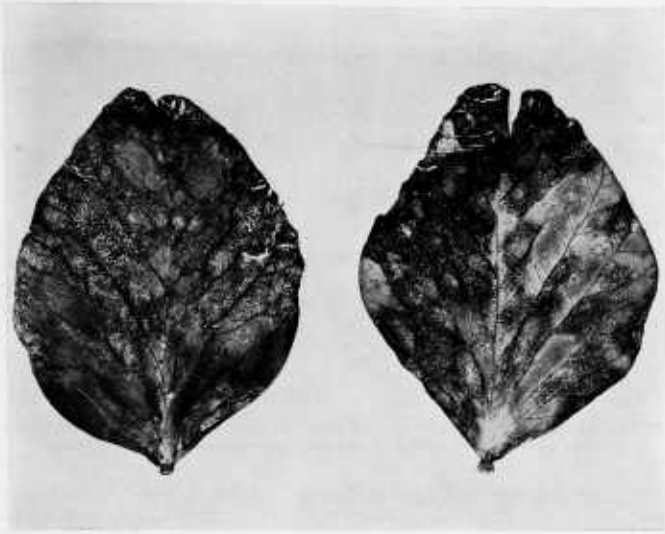

FIGURE 9.—Septoria blight on pea leaves. Note the small, round, black, slightly raised pimples in which the spores of the fungus parasite are produced. These spores escape and start new infections on other leaves, stems, and pods.

toria are somewhat indistinct, whereas those caused by *Ascochyta* are distinct. Ascochyta blight is in part characterized by lesions with ashen-gray centers. With septoria blight, however, the infection begins at the edge of the leaf, causing yellowish indefinite areas that gradually darken and enlarge until the entire leaf is invaded (fig. 9). The casual fungus spreads from the leaves to the nodes, which are likewise yellowed and often shrunken.

Pycnidia, or spore receptacles, more or less indefinitely arranged, develop in the lesions on the leaves, and especially on the nodes and lower part of the stem. Numerous spores are formed in the pycnidia, emerge from them, and are disseminated almost exclusively by spattering rain to other plants, where new infections take place. By this means, an entire field may become infected within a couple of weeks. If infection takes place when the plants are young, that is, 3 to 8 inches high, they will probably die before a crop is produced. If, on the other hand, no infection occurs until the plants are nearly mature, at least a partial crop can be expected.

Septoria blight occurs in epidemic form so infrequently that no chemical control measures have been worked out. Rotation of peas with other crops is suggested if the disease becomes serious.

Powdery Mildew

Powdery mildew of peas is caused by a fungus parasite (*Erysiphe polygoni* DC.) that occurs on beans and other legumes. The organ-

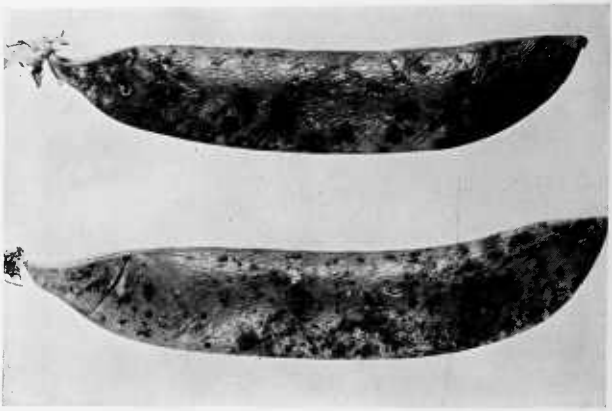

FIGURE 10.—Powdery mildew on pea pods, showing irregularly shaped brown (dark) spots and blotches. Pod infection reduces the market value.

ism causing powdery mildew of peas is probably as widely distributed as is the crop. Like the powdery mildews of other crops, it develops most abundantly under cool conditions. Consequently, it is more prevalent on fall crops or on crops that mature in the late summer and where the nights are cool.

Powdery mildew is characterized by the formation of a white, powdery, dustlike coating on the surface of the leaves and less frequently on the petioles of the leaves, stems, and pods. The leaves are yellowed, dwarfed, and sometimes considerably malformed. Only in extreme cases, however, are the vines killed. In severe cases of the disease, the powdery mildew fungus causes small, brown spots (fig. 10) or streaks on the pods. Damaged pods are not marketable, although the food value of the peas is not affected.

Powdery mildew causes considerable damage in some sections of the country when conditions are favorable for the growth of the causal fungus. Its spores are produced on the surface of the diseased tissues and are disseminated to other plants by air currents and wind. Splashing rain tends to injure the spore-bearing organs and reduces formation of spores. For this reason, the disease is never as destructive in sections of high rainfall or during seasons when rainfall is heavy.

In the pea-growing sections of the States along the Pacific coast and occasionally in other States, control measures are required every year to produce a crop. Dusting the plants with sulfur has given good results. The first dusting should be done as soon as there is any sign of the disease. Another application should be made a week or 10 days later. Sometimes as many as six or seven dustings are necessary to insure a crop. Crop rotation and the immediate turning under of the refuse left in the field after harvest by deep plowing are practices growers should follow. The disease is not seedborne.

Anthracnose

Anthracnose of peas is caused by a fungus parasite (*Colletotrichum pisi* Pat.) that is important only in Wisconsin in some years. It has also been reported from several other States.

On all parts of the plant aboveground, the fungus causing anthracnose produces lesions that resemble those caused by the ascochyta blight fungi (fig. 11). On the leaves it causes irregularly shaped, gray to brown spots; on the pods the spots are more nearly circular. The spots on the stem are elongated and ashen.

The spores are formed in large numbers in the lesions and may be distributed by rain or carried from one plant to another by insects, on farm implements, or by other means. When it is moist, the spores quickly germinate and cause new infections. How the organism survives the winter is not known, but it may live from one season to the next in and on the seed and in the refuse left on the field from a previous crop.

No control measures have been worked out. Crop rotation, plowing under of refuse left on the field, and use of disease-free seed may help to hold the disease in check.

Downy Mildew

Downy mildew is caused by a fungus (*Peronospora pisi* Syd.). This disease, although widely distributed, is not considered of economic importance except in Washington and California and possibly in one or two other Western States. It causes a water-soaked condition of the affected parts and is further characterized by the white, downy, or cottony growth (fig. 12) that may be found on any of the aboveground parts of the plants. This growth occurs on the under sides of the leaves; later their upper sides become yellowed and turn brown, and the leaves die. On the pods, pale-green blotches appear first; later they darken to dark brown mottled with light green. The causal organism grows into the pods and produces a white, felty, hair-like growth. Infected pods may be malformed, and seed from these pods may be infected.

The spores of the causal fungus are spread readily by wind; they may reinfect other plants when the weather is cool and moist. Dry, hot weather checks infection.

No satisfactory control measures have been found for the disease once it is established. A bordeaux spray mixed with Penetrol may offer protection against infection if the fungicide is applied before the disease is noted. In localities where climatic conditions are ideal for development of the disease, a 2-year crop rotation is advised. It is also wise to use seed from arid sections where the disease is not prevalent.

Pea Virus Diseases

Description

Peas are subject to several virus diseases, some of which are readily diagnosed by their symptoms. Others, however, can be identified only by greenhouse tests. Brief descriptions of the most common virus diseases of peas follow.

FIGURE 11.—Anthracnose on pea plants. Note that the spots on the leaves and stems are similar to those of ascochyta blight. They are, however, more distinct and tend to be tan-colored rather than black to purplish. (Courtesy, Wisconsin Agricultural Experiment Station.)

FIGURE 12.—Downy mildew on a pea plant. Note white, cottony growth on leaves.

FIGURE 13.—Mosaic on a pea plant. Note the veins (yellow), which cause a mottled appearance of the infected leaves.

COMMON PEA MOSAIC.—Leaves of plants affected with common pea mosaic show an intermixing of light- and dark-green areas (fig. 13), which are characteristic of mosaics in general. The mottled areas are irregular in outline and may follow the small veinlets. In later stages, these green areas enlarge and become yellowish green, especially along the veins. The leaf then has a netted appearance. When the disease is severe, the leaves may become somewhat curled, twisted, and dwarfed. The symptoms of common mosaic cannot be recognized on the stems or seed; but the pods are frequently distorted, malformed, and dwarfed.

PEA ENATION MOSAIC.—The symptoms of pea enation mosaic consist of mottling, crinkling, and malformation of the leaves and stipules. Yellowish spots develop on the leaves and later become white and somewhat transparent. On very susceptible varieties, necrotic spots appear accompanied by proliferations or enations on the undersurfaces of the leaves that distinguish this virus from others affecting peas. If the plant becomes infected before the pods develop, the pods become very distorted. The pod wall is rough, ridged, and wrinkled and may be so severely twisted or curled that the pods are hardly recognizable. These pods remain severely stunted and produce no seeds.

Pea Stunt.—The most conspicuous symptoms of pea stunt are a severe stunting of the plant and malformation of the apical foliage into a tight rosette of leaves, stipules, and blossoms. The internodes are greatly reduced in length, and diseased plants are often only one-fourth or one-half the size of normal plants. The leaves and stipules are reduced in size, are twisted or curled, and fail to open properly. No mottling of the leaves is noted.

Very few, if any, pods are formed; and those that do develop are stunted and poorly filled. Diseased plants often die prematurely.

Yellow Bean Mosaic.—The virus of yellow bean mosaic causes a distinct mottling of the foliage of peas. The symptoms of this disease are frequently difficult to differentiate from those of common pea mosaic virus, although they are somewhat milder. The first sign of the disease is a faint mottling, which later becomes more intense. Next, a pronounced veinclearing appears; and, adjacent to the larger veins, the dark-green tissue often persists. Between the veins, the leaves remain green; but they are a lighter shade than those of normal plants. Often the edges of the leaves are yellow. Leaves and stipules of infected plants are smaller than normal. Infected plants are only slightly distorted, which helps to differentiate this virus from common and enation pea mosaics, where the distortion is often marked. Pods from yellow bean mosaic-infected plants are somewhat malformed, distorted, and reduced in size but not so severely as are those infected with pea enation mosaic virus.

Pea Streak.—The pea streak virus causes purpling and streaking of the stem, which may extend from the top to the bottom of the plant. The leaves later become flaccid, the tip of the plant begins to wilt, and the plant ultimately dies. A plant infected when young often dies before attaining much growth. If it does not die, it is usually decidedly stunted, the leaves become curled and twisted, and the veins become very pronounced. The pods that are formed before the plant becomes seriously infected take on a dark purplish-gray or brown color. They may also be spotted, pitted, and decidedly malformed. Frequently they do not reach maturity (fig. 14.).

Cause

Each of the several pea virus diseases is caused by a distinct virus. The diseases are discussed together, although they produce different symptoms. All the mosaics and streak are found on other legumes such as red clover, alsike clover, white sweetclover, and alfalfa. The viruses may overwinter on these hosts and be transmitted from them to peas. Not all the viruses infect the same hosts, but they are transmitted to peas from one or more of these crops. In general, these diseases are not seedborne, although common pea mosaic is sometimes carried in very small amounts in the seed.

These diseases are gaining in importance in the United States, and in certain pea-growing localities they cause considerable damage in some seasons by reducing the yield and quality of the product. The severity of the diseases is usually correlated with the size of the pea aphid population. In years of large aphid populations, the virus diseases are more severe than in years when there are fewer aphids.

FIGURE 14.—Pea streak, showing streaking of stem, necrosis of the leaf veins, and malformation of a pod.

Control

No effective control measures are known to combat streak and mosaic. Pea aphids are responsible for much of the spread of these diseases in the field, and controlling them may reduce disease spread.[2] Because of the transmissibility of certain virus diseases of other legumes to peas, peas should not be planted too close to other cultivated legumes, such as clovers and alfalfa. Also, eradicating legumes that grow wild close to peafields may tend to partly reduce the secondary spread of viruses to peas.

The relative susceptibility of the different pea varieties differs with each virus. In general, canning or field varieties are more resistant than are market-garden varieties. Three new canning and freezing varieties resistant to pea enation mosaic have been developed by the New York Agricultural Experiment Station. They are Thomas Laxton 60, Surprise 60, and Perfected Freezer 60. These varieties can be grown where pea enation mosaic is a factor in production. In general, the Perfection varieties are resistant to the several strains of yellow bean mosaic.

NUTRITIONAL DISORDERS

Marsh Spot

Marsh spot, first reported from Holland and other European countries, shows no external symptoms on the plants or on the seeds of peas. When the latter are split open, the flat inner surface of one or both of the cotyledons exhibits a brown cavitylike lesion (fig. 15) sometimes accompanied by a partial or entire necrosis of the plumule that may retard or prevent germination, depending on the size of the lesion. The disorder is generally found on peas planted on alkaline soils but not on those planted on acid soils.

The necrotic lesion enlarges when the seeds approach maturity. It is not found in all seeds of a pod nor in every pod of a plant. Late-maturing varieties with large seeds are more severely affected than are early-maturing varieties with small seeds. Varieties with round seeds (a characteristic usually associated with earliness) are generally free of this condition. Varieties with heavier seeds are more severely damaged.

Marsh spot results from a partial deficiency of available manganese. The amount present may be sufficient for normal vegetative requirement of the plant but not for healthy seed production. Complete absence of manganese produces a mottling of the younger leaves and death of the growing tip, and the plant fails to reach the flowering stage.

Spraying the foliage with a 1-percent manganese sulfate solution at flowering time and 2 or 3 weeks later controls the disorder. Applying heavy soil dressings of a soluble manganese salt at planting has little effect on controlling marsh spot.

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[2] For current recommendations and precautions, see U.S. Dept. Agr., Agr. Handb. 120, Insecticide Recommendations of the Entomology Research Division for the Control of Insects Attacking Crops and Livestock for 1961. This publication is revised each year.

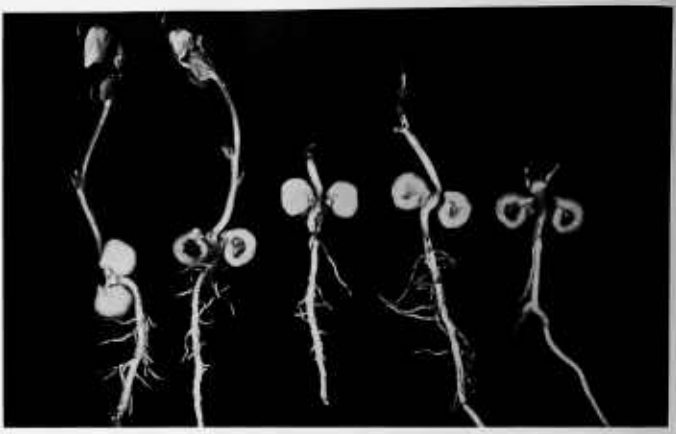

FIGURE 15.—Marsh spot of Dark Skin Perfection variety. Note brown (dark) cavity in cotyledons and necrosis of plumules.

A condition that resembles marsh spot has been found in pea seed from certain areas of Alberta, Canada. When the condition is serious, the stem tip or primary bud dies. This symptom is often accompanied by dark-brown spots on the inner face of cotyledons, but the two symptoms are not always associated in individual seedlings.

Seed Cavitation

The condition known as cavitation, which produces a depressed area in the inner face of the cotyledon that may turn dark, is sometimes widespread in the pea-seed-producing areas of the United States. The cause of this disorder is not yet known but is believed to be nutritional. No plumule abnormalities have been observed, and the symptoms are not necessarily associated with weak seedlings.

Seed cavitation has been found in seed grown in different areas in different years, and it is generally more prevalent among the late-maturing varieties. It has never been observed in Alaska, an early-maturing variety.

Molybdenum Deficiency

Molybdenum deficiency, which is most severe in peas grown on certain acid sandy soils, is expressed as a leaf chlorosis. Peas normally carry enough molybdenum within the seed to supply plant needs. When grown several years on molybdenum-deficient soils, the seeds no longer contain a sufficient amount of the mineral.

The symptoms are somewhat similar to those of nitrogen deficiency in peas, since a lack of molybdenum decreases the availability of nitrogen in the soil. Also, peas suffering from this deficiency cannot form nitrogen-fixing nodules on their roots. The plants may be dwarfed and pale and may exhibit a sudden wilting of the leaves. Scorched

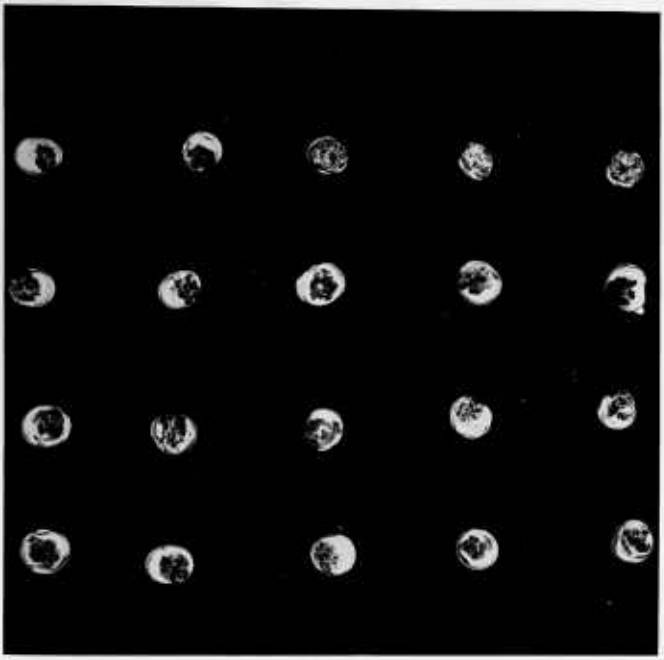

FIGURE 16.—Physiological spotting of Wisconsin Early Sweet pea seed.

leaf margins, suppression of flowering, and poor pod setting may follow.

Peas respond readily to molybdenum fertilization. Two ounces to 1 pound of ammonium molybdate per acre corrects the deficiency. Molybdenum compounds can also be added to the seeds as a seed treatment.

Physiological Spotting of Seed

A spotting of seed, apparently nonparasitic in origin, has been observed since 1930 on peas grown in the States of Wisconsin, Idaho, Montana, and California, and in Sinaloa, Mexico. This spotting has been found only in the Surprise variety and in closely related types such as Peerless, Wisconsin Early Sweet, and Early Canner, and in crosses between Surprise types and other varieties. The spots occur only on the seed, and the pods are normal in every respect. When the seed reaches the canning stage, the spots appear as small, somewhat circular, water-soaked areas that later enlarge slightly. In dry seed, the discolored areas are very conspicuous—they are darker green than normal and in some cases almost black (fig. 16).

Spotted seed is of normal size and germinates just as well as does healthy seed. Not all the pods on a plant produce spotted seed; nor are all the seeds in a pod necessarily affected. Sometimes only one seed in a pod may show spotting; in other instances all the seeds may be affected. Normal seed may under favorable environmental conditions produce spotted progeny. On the other hand, spotted seed does not always produce spotting in the progeny but may do so if conditions are favorable. Seedsmen have reported heavy handpicking costs in areas where this disorder commonly occurs. Handpicking is not recommended as a method of control but only for improving the appearance of the seed stock.

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