Downy Mildew in Spinach

eventual control of damaging disease may be indicated by studies of Iranian spinach

Paul G. Smith

Downy mildew—*Peronospora spinaciae*—is the most important disease of spinach—*Spinacia oleracea*—in California, where it frequently causes major damage to the crop.

Control by sprays or dusts has so far not been practical, and cultural practices apparently have little to do with the mildew epidemics which occur in California.

Spinach in this state is grown primarily as an early spring crop in rotation with more important row crops. Except for a few limited areas of fall production, no spinach is grown for eight months of the year, and the crop seldom succeeds itself on the same ground.

In view of the lack of effective control measures a search for resistance to downy mildew was begun in 1946. Two approaches were made to the problem: *1*, attempts to select resistant plants from large populations of present commercial varieties, all of which are highly susceptible; and *2*, testing of previous untried material.

For testing purposes, about 200 seeds were sown per flat, and the plants inoculated at about the first true leaf stage by spraying with a water suspension of fresh spores of downy mildew. Inoculations were made in a moist chamber in which the plants were kept from 12 to 24 hours before removing to the greenhouse or to the outside.

Infection usually appeared within seven to 14 days; sporulation being induced whenever necessary by returning the plants to the moist chamber overnight.

In the large-scale inoculations during the winter of 1946–47 approximately 15,000 plants of five strains of Hollandia —15,000 plants of two strains of Viroflay and 5,000 of Giant Nobel were tested.

From these, 36 plants of Viroflay, 32 of Hollandia and four of Nobel appeared to possess resistance and were saved for seed production. These surviving plants of each variety were then planted together and allowed to interpollinate, each variety being kept isolated.

Since spinach is dioecious—having staminate and pistillate flowers on different individual plants—only 16 Viroflay, 13 Prickly Winter and one Nobel plants produced seeds.

Seed of each plant was saved separately and grown for testing in the fall of 1947.

On inoculation, all were as severely diseased as the respective parent varieties. Thus the possibility of selecting even a partial degree of resistance to downy mildew from the susceptible commercial varieties appears to be exceedingly remote.

The following commercial varieties were tested and all found to be highly susceptible:

- Amsterdam Giant
- Bloomsdale, Long Standing
- Bloomsdale Savoy
- Broadleaved Prickly
- Deventer Green
- El-De-Es
- Hollandia
- Juliana
- King of Denmark
- Morse's Dark Green Prickly
- Giant Nobel
- Old Dominion
- Prickly Winter
- Prickly Winter—original strain
- Supra
- Utecht Winter
- Viking
- Virginia Savoy
- Viroflay

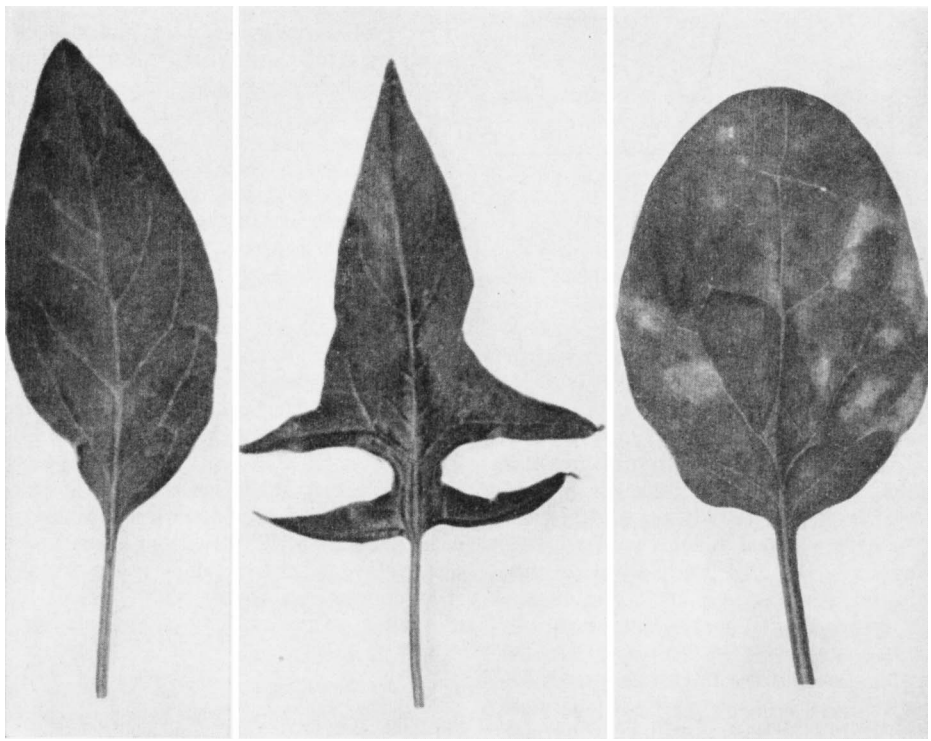
After the above testing had been largely completed, nine lots of seed collected in Iran by the Division of Plant Exploration and Introduction, U.S.D.A., became available for testing. Two of these lots were found to be mixtures of susceptible and resistant plants. Neither lot proved suitable for cultivation; having small, thin leaves of varying shape; very high oxalic acid content and early bolting habit.

Disease-free Iranian plants were interplanted in isolation plots with plants of Hollandia and Viroflay. A good seed yield was obtained, indicating a high degree of cross-fertility. Since the commercial varieties were genetically susceptible no attempt was made to use individual plants as pollen parents.

Inoculation and inspection of plants of the parent and hybrid lines revealed only two classes of plants: badly diseased; and clean, with no intermediate levels of resistance evident. Careful examination of disease-free plants failed to reveal any

Continued on next page

Young leaves from two downy mildew immune spinach plants of P.I. 140, 467—*left and center*—and infected leaf of the susceptible Viroflay variety—*right*. All three were inoculated at the same time.



PHOSPHATE

Continued from page 11

concentrations greater than 0.50 ppm deficiency is unlikely to occur—only two out of 30 soils gave a response.

In the light of field and greenhouse results, the following ranges of phosphate in water extract are suggested for tentatively defining the status of available phosphorus in a given soil.

Class *1*. Response likely, less than 0.30 parts per million of phosphate.

Class *2*. Response uncertain, from 0.30 to 0.50 parts per million of phosphate.

Class *3*. Response unlikely, greater than 0.50 parts per million of phosphate. It must be emphasized that these ranges of phosphate are expressed on the solution basis.

An anticipated response to phosphate fertilization implies that only phosphorus is the limiting element and that there exists no toxic condition in the soil. In California often nitrogen must be added to secure a phosphate response.

In the case of a phosphorus-deficient soil, response can be expected only when sufficient amounts of phosphate have been added. In the case of a soil containing minerals of the kaolinite type, fixation would be great. This would require considerably more phosphate for a response or a banding of the fertilizer in the immediate vicinity of the roots.

The ranges of phosphate suggested for interpretation of the chemical extraction apply only to the crops listed, mainly pastures, field crops and truck crops.

Field experiments suggest that these responses are especially pronounced for winter crops.

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The above progress report is based on Research Project No. 1157.

CLINGS

Continued from page 9

is becoming moist is to compare the thermometer readings.

Because of the large trimming losses—pits and peel—the over-all drying ratio is less favorable than for other fruit. A good quality fruit dries about 9:1 and a higher ratio is found for orchard run lots.

To complete the reduction of moisture content to about 20%, the fruit is removed from the dehydrater and allowed to stand for several hours.

In foggy climates this plan can not be followed, for standing fruit might actually absorb additional moisture from the air. In such places, the temperature at the finishing end of the tunnel is reduced to about 150° F and the drying finally completed while the fruit is still in the tunnel.

The cooled fruit is removed from the trays to clean, wooden boxes for temporary storage before shipping.

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CITRUS

Continued from page 10

aration of 500 gallons of 2,4-D spray are given in the accompanying table.

Experimentally the spray has been applied as a complete coverage spray of from 15 to 20 gallons per tree to as little as about six gallons per tree. Applications of four gallons per tree or less do not appear to be satisfactory at the concentrations listed. It seems reasonable to expect that spray-dusters, boom sprayers, or other equipment applying at least six gallons per tree of the 2,4-D sprays listed, would be satisfactory.

Much more information is needed on application methods before more than these tentative conclusions may be drawn.

Inasmuch as 2,4-D used to reduce mature fruit drop has been found to be compatible with the usual spray chemicals, it seems likely that when used at somewhat higher concentrations for fruit size increase it will likewise be compatible.

When applying 2,4-D, it seems desirable to reduce the curling of the new young leaves by delaying application until after the spring leaf growth has occurred. In some trials, although leaf curling has been severe, it has not reduced production of fruit quality. Succeeding leaf growth flushes usually have appeared normal.

Spraying Valencia oranges and grapefruit with 2,4-D to increase fruit size of next season's crop has not been found to increase fruit size of the current, mature crop. It will, however, effectively reduce mature fruit-drop of the current crop.

Trials are now in progress to compare 2,4-D with 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) and other chlorinated phenoxy acids for effectiveness in increasing fruit size. Preliminary data indicate that 2,4,5-T is at least as effective as 2,4-D.

The over-all effect of 2,4-D sprays to increase citrus fruit size seems to be an accentuation of the juvenile characteristics of the fruit. This includes large fruit size, delayed maturity, dark green young fruit; somewhat rough, pebbly rind to maturity; and thick fruit-stems.

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SPINACH

Continued from preceding page

trace of fungus penetration or development. The freedom from disease, then, can be considered to be true immunity, rather than high-level resistance.

The consistent reaction of the immune stocks during the winters of 1947–48 and 1948–49, have not suggested the presence of any physiologic strains of the fungus in the Davis areas, although there was ample opportunity for infection from natural sources throughout the course of the experiments.

Because of the predominantly dioecious habit of spinach, self-pollination is not normally possible. Inheritance data, therefore, have been secured on the first generation resulting from the cross between immune and susceptible plants and on the first backcross of immune first generation plants to the susceptible types.

The results of these experiments have shown that immunity is simply inherited as a single dominant genetic character. Because of this, it will be possible to transfer to commercial spinach varieties the complete freedom from downy mildew which has been found in the Iranian variety.

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TIMBER

Continued from page 7

Whitaker's Forest is situated in one of the most productive timber types in California. Sugar pine, ponderosa pine and white fir are all important timber trees, and the sequoias here have demonstrated their ability to grow in height and volume at a rate exceeding that of most softwood tree species.

The east portion of the forest above the camp clearing is cooler and somewhat more moist than the west portion and contains a mixed stand of sugar pine, white fir and sequoia with occasional incense cedars and black oaks.

Ponderosa pines appear in greater number towards the west with increase in warmth and dryness and the sequoias drop out of the stand before the west boundary is reached.

From there west on the National Forest there are virtually no sequoias at this elevation. A heavy stand of mature ponderosa pine on the ridge west of the property produced a large volume of timber when cut under National Forest timber sale in 1944 and 1945.

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