Some Sources of Resistance in Crop Plants

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We give in this chapter a list of crop plants and the diseases to which resistance has been found. Listed in order are the name of the crop, the disease (with the causative organism), the original source of resistance (O. S. R.), the present source of resistance (P. S. R.), and the mode of inheritance.

The abbreviation C. I. stands for Cereal Investigations—an accession number that, like a name, is assigned to a new variety of cereal grain.

In many instances the inheritance is reported as unknown or undetermined. Often the breeding behavior of the character for resistance is known, but the exact number of genes involved has not been determined. Some of the factors that make it hard to give a definite genetic explanation are multiple genes, polyploidy, physiologic races of causative organisms, and the effects of environment.

Write to your State agricultural experiment station for information concerning the sources of plant materials listed in this chapter.

For many diseases of crop plants there is still no known source of resistance. The search, however, is going forward steadily. If crop failures are to be avoided, new sources and higher levels of resistance to many destructive diseases have to be located. Undoubtedly many new sources of resistance will be uncovered in wild and cultivated species to be added to this already imposing list.

For further reading:

Breeding disease resistant varieties:


Variability of fungi:


Nature of disease resistance:


Nutritional aspects:


CEREALS: barley, corn, oats, rice, wheat.

BARLEY


LEAF RUST, Puccinia hordei. O. S. R.: Bolivia C. I. 1257 and 100 to 200 additional varieties in the barley world collection. P. S. R.: Commercial varieties having leaf rust resistance often derived this resistance from the sources in O. S. R. Inheritance: Monogenic dominant in most crosses; an additional gene may be present in some varieties.


LOOSE SMUT, Ustilago nuda. O. S. R.: Jet C. I. 967, Trebi C. I. 936, Valentine C. I. 7242, Ogalitsu C. I. 7152, Anoidium C. I. 7269, Abyssinian C. I. 668, Bilarb C. I. 3951–3, Kitchin C. I. 1296, Afghanistan C. I. 4173, Suchow C. I. 5901, C. I. 4966, a number of hooded winter barley selections from Tennessee Beardless and Missouri Early Beardless, and other varieties in the world collection. P. S. R.: Resistance genes from some of these varieties now have been transferred to commercial varieties; for example, Velvon, Titan, Tregal, etc. Inheritance: Four resistant genes have been identified so far, two of which are dominant and two are intermediate in effect. The smut gene in Valentine is closely linked with the gene for stem rust resistance.

NET BLOTCH, Pyrenophora teres. O. S. R.: Canadian Lake Shore C. I. 2750, Tifang C. I. 4407–1, Manchu C. I. 4795, Ming C. I. 4797, Harbin C. I. 4929, Velvet 26–95, C. I. 5084, and about 70 additional varieties in the barley world collection. P. S. R.: Partial protection to this disease now is present in some commercial varieties, which derived their germ plasm from barleys coming from Manchuria. Inheritance: Undetermined.

POWDERY MILDEW, Erysiphe graminis. O. S. R.: Duplex C. I. 2433, Hanna C. I. 906, Goldfoil C. I. 928, Arlington Awnless C. I. 702, Chinerme C. I. 1079, Algerian C. I. 1179, Kwan C. I. 1016, Psaknon C. I. 6305, Monte Cristo C. I. 1017, West China C. I. 7556, and many other varieties in the barley world collection. P. S. R.: Resistance to this disease is now found in several commercial varieties; for example, Atlas 46 and Erie. Inheritance: Nine dominant or incompletely dominant and three recessive genes for reaction to race 3 have been located.


SCALD, Rhynchosporium secalis. O. S. R.: Turk C. I. 5611–2, La Mesita C. I. 7565, Modoc C. I. 7566, Trebi C. I. 936, and a number of additional varieties in the barley world collection. P. S. R.: Resistance to scald is present in Atlas 46, which was derived from the variety Turk.

world collection. P. S. R.: The resistance in Moore is an example of the transfer of resistance from Chevron/Olli.

Stem rust, *Puccinia graminis*. O. S. R.: Chevron C. I. 1111, Peatland C. I. 5267, Hietpas 5 C. I. 7124, Kindred C. I. 6969, and about 50 additional varieties in the barley world collection. P. S. R.: Several commercial varieties; for example, Mars, Moore, Kindred Feebar, and Plains. Inheritance: Monogenic dominant; an additional gene may be present in some varieties.

Stripe, *Helminthosporium gramineum*. O. S. R.: Hannchen C. I. 531, Trebi C. I. 936, Club Mariout C. I. 261, Persicum C. I. 6531, Brachytic C. I. 6572, Lion 923, and others in the barley world collection. P. S. R.: Same as preceding. Inheritance: Six or more separate genes are involved and various degrees of dominance have been encountered.

**CORN**


Rust, *Puccinia polysora*. O. S. R.: Little critical information available but in a greenhouse test inoculated when 6 weeks old, the following lines were resistant to infection: Hy, W22, 461-3, 38-11, Ohio 07, K148, T14, and C. I. 15. P. S. R.: Same as preceding. Inheritance: Unknown; probably polygenic.


**OATS**


Bacterial stripe blight, *Pseudomonas striafaciens*. P. S. R.: Aurora, Coastblack, Colburt, Culberson, Fulghum, Navarro, Red Rustproof, Ru-


**Crown rust, Puccinia coronata avenae.** P. S. R.: Arkansas 674, Bond, Bondvic, Landhafcr, Santa Fe, Trispernia, Ukraine, Victoria, and many derivatives of preceding. Inheritance: Monogenic to polygenic.


**Septoria leaf spot and black stem, Leptosphaeria avenaria.** P. S. R.: Anthony-Bond x Boone, Ajax, Beaver, Branch, Clintafe, Clinton, Shelby, Spooner. Inheritance: Unknown.

**Stem rust, Puccinia graminis avenae.** P. S. R.: Canuck (Hajira x Joannette), Clinton x Ukraine (C. I. 5871), Joanette strain, Richland, Victoria x (Hajira x Banner), White Tartar, and many derivatives of preceding. Inheritance: Monogenic.


**Rice**


**Wheat**


FIBER CROPS: cotton, fiber flax.

COTTON


FIBER FLAX


FORAGE CROPS: alfalfa, clover, cowpeas, southern legumes, soybeans.

ALFALFA

in 1898 (Turkistan) and north India in 1910 (Ladak). P. S. R.: Commercial varieties Ranger and Buffalo. Inheritance: Resistance is partially dominant, polygenic.


**Crown rot, Fusarium sp.** O. S. R.: Same as preceding. Inheritance: Unknown.


**Clover**


**Large hop clover**

**Powdery mildew, Erysiphe polygoni.** O. S. R.: Individual plant from a farm seed lot. P. S. R.: Resistant line in breeding material, North Florida Agricultural Experiment Station. Inheritance: Unknown.

**Red clover**

**Crown rot, Sclerotinia trifoliorum.** O. S. R.: Slight resistance in some farm strains grown where the organism is prevalent. P. S. R.: Slight resistance in Kenland, Kentucky Agricultural Experiment Station; in Stevens, Maryland Agricultural Experiment Station; and in Pennscott, Pennsylvania Agricultural Experiment Station. Abridged list, Sanford, Virginia Agricultural Experiment Station. Inheritance: Unknown.

**Northern anthracnose, Kabatiella caulivora.** O. S. R.: Slight resistance in some farm strains grown where the organism is prevalent. P. S. R.: Highly resistant lines in breeding material, Wisconsin Agricultural Experiment Station; moderate resistance in Doldard, McDonald College, Quebec, Canada; some resistance in variety Ottawa, Dominion Experiment Farm, Ontario, Canada; abridged list, Purdue, Indiana Agricultural Experiment Station; and Midland, composite of selected farm strains. Inheritance: Unknown.

**Powdery mildew, Erysiphe polygoni.** O. S. R.: Occasional plants of farm


**Southern Anthracnose**, *Colletotrichum trifolii*. O. S. R.: Some resistance in most of the farm strains grown where the organism is prevalent. P. S. R.: High resistance in Kenland, Kentucky Agricultural Experiment Station; in Tennessee Purple Seeded, Tennessee Agricultural Experiment Station. Some resistance in Tennessee Anthracnose Resistant, Tennessee Agricultural Experiment Station; in Kentucky 215, Kentucky. Abridged list, Sanford, Virginia; Pennscott, Pennsylvania; Stevens, Maryland; and Cumberland, composite of selected strains. Inheritance: Unknown.

**Sub Clover**


**White Clover**

**Crown Rot**, *Sclerotinia trifoliorum*. O. S. R.: Slight resistance in some seed lots that are grown where the organism is prevalent. P. S. R.: Willamette, Oregon Agricultural Experiment Station. Inheritance: Unknown.


**Root Rot**, *Phytophthora cactorum*. O. S. R.: Some resistance in some common seed stocks grown where the organism is prevalent. P. S. R.: Highly resistant lines in breeding material, Wisconsin Agricultural Experiment Station and Illinois Agricultural Experiment Station. Inheritance: Possibly polygenic dominant.

**Southern Anthracnose**, *Colletotrichum trifolii*. O. S. R.: Some resistance in domestic seed lots. P. S. R.: High resistance in N-1, Nebraska Agricultural Experiment Station and in lines of breeding material, Wisconsin Agricultural Experiment Station. Inheritance: Unknown.

**Cowpeas**

**Bacterial Canker**, *Xanthomonas vignicola*. O. S. R.: Brabham (Iron x Whippoorwill), Buff, Iron, Six-Weeks-Ala., Suwannee, and Victor (Groit x Brabham); *V. sinensis*, P. E. I. Nos. 152199 from Paraguay, 167284 from Turkey, and 186456 from Nigeria; *Vigna spp.* P. E. I. Nos. 158831 from Paraguay, 171985 from Dominican Republic, 182025 from Liberia, 124606 from India, 159210 from Union of South Africa. Inheritance: Unknown.
Nigeria; and selections from Chinese Red x Iron and Blackeye x Iron hybrids available from the Division of Plant Exploration and Introduction, United States Department of Agriculture. Inheritance: Resistance is a monogenic dominant.


**Powdery mildew**, *Erysiphe polygoni*. O. S. R.: *Vigna sesquipedalis* (Asparagus bean, Yardlong bean). P. S. R.: Selection from Yardlong x "Azul Grande" (New Era x Sugar Crowder selection) developed at Turrialba, Costa Rica. Inheritance: Multiple factor with resistance recessive. There are conflicting reports in the literature on mode of inheritance, which suggests the possibility of distinct races of the pathogen.


### Southern Legumes

**Blue lupine** (*Lupinus angustifolium*)


**Lespedeza stipulacea**

**Powdery mildew**, *Microsphaera difussa*. O. S. R.: Old fields of lespedeza. P. S. R.: Commercial variety Rowan is being released. Inheritance: Conditioned by at least two genes. One or more of these genes are linked with certain genes associated with flower color.

**Winter field pea** (*Pisum arvense*)


### Soybeans


**Downy mildew**, *Peronospora manshurica* (3 physiologic races known). O. S. R.: Races 1 and 3 and moderate resistance to race 2: Chief, Dunfield, Manchu 3, Mukden, T 117; races unknown: Acadian and Ogden. P. S. R.: Races 1 and 3 and moderate resistance to race 2: Chief, Dunfield, Manchu 3, Mukden, T 117; races unknown: Acadian and Ogden. Inheritance: Resistance to each of races 1, 2, and 3 is monogenic dominant. Resistance to
race 3 of Richland is conditioned by two genes.


Purple seed stain, Cercospora kikuchii. O. S. R.: CNS. P. S. R.: N46-2566 (S100 x CNS), N49-2560 (S100 x CNS), CNS. Inheritance: Undetermined.


Root knot, Meloidogyne spp. (soybeans attacked by five species). O. S. R.: Resistant to some species of nematodes: Palmetto, S100, and Laredo. P. S. R.: Resistant to some species of nematodes: Palmetto, S100, N45-3799 (Palmetto x Ogden), N46-2566 (S100 x CNS), N46-2652 (Volstate x Palmetto), and Laredo. Inheritance: Undetermined.

FORESTRY: American chestnut, American elm, European field elm, mimosa, white pine.

AMERICAN CHESTNUT

Chesnut blight, Endothia parasitica. O. S. R.: Asiatic chestnut trees, particularly the Chinese chestnut and the Japanese chestnut. P. S. R.: Outstanding strains are being selected from introductions by the United States Department of Agriculture from the Orient made between 1927 and 1932. Resistant hybrids between the Asiatic chestnuts and the native American chestnuts are being developed. Chinese chestnut trees, for nut production and ornamental use, are for sale by commercial nurserymen. Inheritance: Unknown.

AMERICAN ELM


EUROPEAN FIELD ELM


MIMOSA


WHITE PINE

White pine blister rust, Cronartium ribicola. O. S. R.: Resistant strains of the white pine. P. S. R.: Resistant selections of white pine have been obtained and are being propagated
vegetatively by rooted cuttings. Inheritance: Unknown.

FRUITS: Apple, apricot, blackberry, blueberry, cranberry, grapes, muscadine grapes, peach, pear, raspberry, strawberry.

APPLE

Fire blight, Erwinia amylovora. O. S. R.: Immunity has not been satisfactorily demonstrated. Somewhat resistant commercial varieties include Delicious, Arkansas Black, and Winesap. Inheritance: Polygenic; resistance partially dominant.

Apple scab, Venturia inaequalis. O. S. R.: Malus atrosanguinea (804), M. floribunda (821), M. micromalus (245-38), M. prunifolia (19651), M. pumila (R No. 12740-7A), M. zuni calocarpa, Antonovka, and others. P. S. R.: Cathay, Elk River, Kola, Red Tip, S. D. Jonsib, Tipi, Zapata, and commercial types now being developed. Inheritance: Monogenic dominant in M. floribunda (821); two dominant genes in M. micromalus (245-38); three dominant genes in M. pumila (R No. 12740-7A); probably one major dominant gene in M. atrosanguinea (804), M. prunifolia (19651), and M. zuni calocarpa. Polygenic in Antonovka. All clones listed are heterozygous for the resistant genes as listed.

Cedar-apple rust, Gymnosporangium juniperi-virginianae. O. S. R.: Arkansas Black, Delicious, McIntosh, Macoun, Winesap, and Wolf River. P. S. R.: Same as preceding. Inheritance: Monogenic dominant. Arkansas Black and McIntosh are homozygous, whereas others listed are heterozygous resistant.

APRICOT


BLACKBERRY


BLUEBERRY

Stem canker, Physalospora corticis. O. S. R.: Crabb 6 selected from wild type in North Carolina and selections from commercial varieties. P. S. R.: Varieties Wolcott, Murphy, Angola, Crabb 6, Adams, Scammell, Jersey, Rubel, Harding, and all rabbiteye varieties selected from wild. Inheritance: Resistance probably dominant.


CRANBERRY

False blossom, Chlorogenus vaccinii. O. S. R.: Various selections from wild cranberries in the eastern United States, including the commercial varieties McFarlin, Early Black, and Shaw’s Success. P. S. R.: The preceding varieties and the recently introduced Wilcox variety. Hybrid selec-
tions are now under test by the United States Department of Agriculture and cooperating agencies. Inheritance: Resistance is actually klendusity, or escape, because the insect vectors do not feed on the plants. Klendusity is controlled by multiple factors.

**Grapes**

**Downy Mildew, Plasmopara viticola.** O. S. R.: Black Monukka; Jaeger 70; certain selections of *Vitis rupestris*, such as Rupestris Martin and Rupestris Mission; *V. lincecumii*; several selections of *V. cinerea* Nos. 23, 24, 27, 45, 47, 48, and 54; *V. cordifolia* Nos. 15 and 29; and *V. riparia* Nos. 13 and 50. P. S. R.: S. V. 12–375, 12–309, 12–309, 12–401, 23–18, 23–657, S. 6768, 5813, 14664, 15062, and 12 named varieties are reported highly resistant. Inheritance: Multiple factor.


**Anthracnose, Sphaceloma ampelinum.** O. S. R.: Selections of *Vitis cinerea* Nos. 23, 24, 27, 45, 47, and 54; *V. cordifolia* No. 15; and *V. riparia* Nos. 13 and 50. P. S. R.: S. 5455, S. V. 12–413, and 23–501. Inheritance: Resistance recessive, multiple factor.

**Black Rot, Guignardia bidwellii.** O. S. R.: Selections from several wild species of *Vitis*, principally *V. cinerea*, *V. cordifolia*, and *V. rupestris*; selections of *V. cinerea* Nos. 23, 24, 27, 45, 47, 48, and 54; and *V. cordifolia* Nos. 15 and 29 have thus far been free of the black rot. Rupestris Martin, a rootstock variety, and Seibcl 1,000, a French hybrid wine type, have shown no infection. In the literature Conderc Nos. 28–112, 175–38, 3304, and 162–97 are reported as immune, and 30 varieties are reported as highly resistant. P. S. R.: Preceding varieties and commercial types now being developed. Inheritance: Unpublished data on several thousand vines artificially inoculated with the organism indicate that the resistance is apparently multiple factor with the very high resistance of *V. cinerea* strongly dominant in most crosses.

**Muscadine Grape**


**Pear**

**Black Rot, Guignardia bidwillii.** O. S. R.: Unknown. P. S. R.: Varieties such as Hiley Ranger and Belle of Georgia. Inheritance: Multiple factor.


**Pear Mosaic, Marmor persicae.** O. S. R. (Here we are dealing with tolerance and not resistance). Many varieties of clingstone, such as Paloro, Peak, Phillips, and Sims, and a few varieties of freestone peaches, such as Erly-Red-Fre, Fisher, and Valiant, are highly tolerant. Most of the freestones become severely damaged. P. S. R.: Commercial varieties, mostly of the clingstone type, are tolerant. Symptom development is complicated by many strains of the virus. Inheritance: Unknown.
important varieties Bosc is one of the most seriously affected. The Waite variety is susceptible, and since this is probably a cross between Bartlett and another variety, it appears the symptomless characters are not dominant.

**Fire blight**, *Erwinia amylovora*.
P. S. R.: Immune, Richard Peters; highly resistant, Orient, Hood, and Pineapple; fairly resistant, Baldwin, Waite, and Ewart; slightly resistant, Kieffer.

**Raspberry**


**Strawberry**


**Red stele**, *Phytophthora fragariae* (two races). O. S. R.: The variety Aberdeen in the United States, a chance seedling that originated in New Jersey, and Scotland No. 52 of the West of Scotland Agricultural Experiment Station. P. S. R.: The varieties Temple, Fairland, Sparkle, Redcrop, Pathfinder, and Vermilion, and the Scottish variety Climax. Selections from the breeding work of the United States Department of Agriculture and the Maryland and Oregon Agricultural Experiment Stations. Inheritance: Multiple factor with resistance partially dominant but complicated by several physiologic races.


**Grasses**: Bahiagrass, Bermuda-grass, smooth brome, mountain brome, orchardgrass, slender wheatgrass, Sudangrass, tall fescue, meadow fescue, tall oatgrass, timothy, western wheatgrass, sand bluestem, side-oats grama, blue grama, buffalograss.

**Bahiagrass** (*Paspalum notatum*)


**Bermuda-grass** (*Cynodon dactylon*)

*Helminthosporium cynodontis*. O. S. R.: Collection of United States Department of Agriculture, which was col-

**SMOOTH BROME (Bromus inermis)**


**MOUNTAIN BROME (Bromus marginatus)**


**ORCHARDGRASS (Dactylis glomerata)**


**SLENDER WHEATGRASS (Agropyron trachycaulum)**


**TALL FESCUE (Festuca arundinacea)**


**MEADOW FESCUE (Festuca elatior)**

*Crown rust*, *Puccinia coronata*. O. S. R.: Two plants selected from old field in Maine. P. S. R.: Selections have not been increased. Inheritance: Multiple factors.

**TALL OATGRASS (Arrhenatherum elatius)**


**TIMOTHY (Phleum pratense)**


**SUDANGRASS (Sorghum vulgare var. sudanense)**


Inheritance: Probably multiple factor.


**WesterN WHEATGRASS (Agropyron smithii)**

*Rust*, *Puccinia rubigo-vera*. O. S. R.: Some selected individuals appear to be

**SAND BLUESTEM** (*Andropogon hallii*)


**SIDE-OATS GRAMA** (*Bouteloua curtipendula*)


**BLUE GRAMA** (*Bouteloua gracilis*)


**BUFFALOGRASS** (*Buchloë dactyloides*)


**HOPS**


NUTS: Chinese chestnut, filbert, pecan, Persian (English) walnut, eastern black walnut.


**TWIG CANKER**, *Cryptodiaporthe castanea*. O. S. R.: All varieties and seedlings are resistant when grown on proper sites. P. S. R.: All varieties and seedlings.

**FILBERT**


**PECAN**


**BUNCH DISEASE**, or Witches'-broom, virus. O. S. R.: Great difference in varieties; Schley and Mahan most susceptible. Stuart resistant or symptomless carrier. P. S. R.: Stuart.

**DOWNY SPOT**, *Mycosphaerella caryigena*. O. S. R.: Schley and a few other varieties are highly resistant. P. S. R.: Schley and a few other varieties.

**PERSIAN (ENGLISH) WALNUT**

Walnut bacterial blight, *Xanthomonas juglandis*. O. S. R.: Immunity
not known. Eureka, San Jose, and Ehrhardt show some degree of resistance. Some seedling trees are seldom badly infected. In Oregon the Pari-sienne variety is somewhat resistant. Resistant varieties came originally from seedlings from a mixed population. P. S. R.: Eureka, San Jose, and Ehrhardt. Inheritance: Unknown.

**Branch Wilt,** *Hendersonula turiculoidea.*** O. S. R.: Meylan, Eureka, Blackmer, Payne, and Concord are somewhat resistant. Concord is the most resistant of all. Varieties originally came from seedlings from a mixed population. P. S. R.: Preceding varieties. Inheritance: Unknown.


**Root Lesion, nematode injury,** *Paratylenchus vulnus* and *Cacopaurus pestis.* O. S. R.: All Persian varieties are susceptible; Paradox hybrids (Persian x *J. hindsii*) show some resistance. P. S. R.: Commercial Paradox hybrids. Inheritance: Unknown.

**Eastern Black Walnut**


**Oil Plants:** grain flax, safflower, peppermint, spearmint.

**Grain Flax**


**Safflower**

**Rust, Puccinia carthami.** O. S. R.: Introductions by Nebraska Agricultural Experiment Station from Romania, Turkey, India, Egypt, and France. Resistant lines have been purified by the Nebraska Agricultural Experiment Station; others are being developed by the United States Department of Agriculture. Inheritance: Resistance is monogenic dominant.

**Root rot, Phytophthora dreschleri.** O. S. R.: Introductions by the Nebraska Agricultural Experiment Station from Egypt and other introductions presumed to have originated in Russia. P. S. R.: Various degrees of root rot resistance in commercial varieties N-3, N-4, N-6, and N-8, developed by Nebraska Agricultural Experiment Station. Root rot resistant varieties are in process of development by the United States Department of Agriculture. Inheritance: Unknown.

**Peppermint**


**Spearmint**

**Spearmint rust, Puccinia menthae.** O. S. R.: *Mentha crispa* from unknown European source. P. S. R.: Clonal line maintained at Michigan State College in regional mint nursery, East Lant-
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Snapdragon

Rust, Puccinia antirrhini. O. S. R.: Antirrhinum majus strains from Dr. E. B. Mains. P. S. R.: The varieties Artistic, Campfire, Loveliness, Red Cross, Snow Giant, Yellow Giant, Rosalie, Alaska, Apple Blossom, Canary Bird, Copper King, Crimson, and other commercial types now being developed. Inheritance: Monogenic dominant.

Sugar Crops: Sorgo, sugar beet, sugarcane.

Sorgo


Sugar beet

Black root, Aphanomyces cochlioides. O. S. R.: U. S. 216 and other U. S. varieties developed in leaf-spot resistance breeding project. P. S. R.: Seed increase of S. P. I. 48B3-00, now released as U. S. 1177, and related varieties; also varieties developed by beet sugar industry. Inheritance: Resistance is dominant in F1, resistant x susceptible. Evidently disease reaction is conditioned by more than one pair of genes.

Cercospora leaf spot, Cercospora beticola. O. S. R.: Inbred lines established from European open-pollinated varieties. P. S. R.: U. S. 216, U. S. 225, U. S. 226, and hybrid combinations of these; also in varieties developed by the beet sugar industry. Inheritance: Disease reaction of the F1, resistant x susceptible, is intermediate. Segregation in F2 indicates that disease reaction is conditioned by more than a single pair of genes.


Sugarcane

Red rot, Physalospora tucumanensis. O. S. R.: Some forms of Saccharum spontaneum and probably of S. barberi. P. S. R.: Commercial and unreleased clones that are interspecific hybrids with S. spontaneum or S. barberi inheritance, such as CO 261, CP 28/11, CP 36/105, and CP 44/101. Inheritance: Undetermined.

Root rot, Pythium arrhenomanes. O. S. R.: Various forms of Saccharum spontaneum and S. sinense. P. S. R.: Some commercial and unreleased clones that are interspecific hybrids with inheritance from these species, such as CO 290, CP 28/11, CP 807, CP 33/409, and Kassoer. Inheritance: Undetermined.

Mosaic, Marmor sacchari. O. S. R.: All known forms of Saccharum spontaneum except those from Turkestan. P. S. R.: Numerous commercial and unreleased clones that are interspecific hybrids, usually with S. spontaneum inheritance. Inheritance: Undetermined.

Tobacco


VEGETABLES: asparagus, bean, celery, crucifers, cucumber, lettuce, lima bean, muskmelons, onion, pea, peanut, peppers, potatoes, spinach, sweetpotato, tomato, watermelon.

ASPARAGUS


BEAN

HALO BACTERIAL BLIGHT, *Pseudomonas phaseolicola*. O. S. R.: Most field bean varieties: Pinto, Great Northern, Michelite, and Red Mexican. P. S. R.: Preceding varieties; Pinto, University of Idaho Nos. 72, 78, and 111; Great Northern, University of Idaho Nos. 16, 31, and 123; Michelite and Red Mexican, University of Idaho Nos. 3 and 34; and Fullgreen. Inheritance: One or two recessive factors depending on the resistant and susceptible parents used.

ANTHRACNOSE, *Colletotrichum lindemuthianum*. O. S. R.: Alpha race: Wells Red Kidney, Cranberry, and Emmerson 847. Beta race: Michelite, Pinto, Perry Marrow, and Emmerson 847. Gamma race: Robust, Perry Marrow, and California Small White. P. S. R.: Red Kidney and the preceding varieties. No commercial varieties are resistant to the three races. Inheritance: Single dominant factor pair for each race. When two or three races are involved resistance is governed by two or three dominant factor pair differences, respectively.

BEAN RUST, *Uromyces phaseoli typica*. O. S. R.: No strain is resistant to all physiologic races. A number are resistant to most of the races: No. 780, a White Kentucky Wonder type; No. 765, a Kentucky Wonder Wax type; and No. 814, a brown-seeded Kentucky Wonder Wax type. P. S. R.: U. S. Pinto Nos. 5 and 14 and Golden Gate Wax. Inheritance: Single dominant factor pair for each race thus far investigated.

POWDERY MILDEW, *Erysiphe polygoni*. O. S. R.: No strain or variety is resistant to all races. Pinto, U. S. 5 Refugee, and Ideal Market are resistant to a number of races. P. S. R.: Available in the preceding varieties and in others, such as Topcrop, Logan, and Contender. Inheritance: Single dominant factor pair.

Curly Top, *Ruga verrucosans*. O. S. R.: Varieties Pioneer, California Pink, Burtner's Blightless, and Red Mexican. P. S. R.: Red Mexican, University of Idaho Nos. 3 and 34; Great Northern, University of Idaho Nos. 16 and 31; and Pinto, University of Idaho Nos. 72, 78, and 111. Inheritance: Resistance is probably controlled by two genes, one of which is dominant to its allele, the other recessive to its allele. In a progeny segregating for both, the gene that is dominant to its allele is epistatic to the gene that is recessive to its allele.


Celery

Early Blight, *Cercospora api*. O. S. R.: Danish celery received for trial by Eastern States Farmers' Exchange; P. E. I. 176869 from Turkey may have a little higher resistance; and P. E. I. 115557 and P. E. I. 120875 from Turkey. P. S. R.: Emerson Pascal, Giant Pascal, and White Plume have moderate resistance. Breeding lines with high resistance are available but they are far from commercial type. Inheritance: Multiple factor.


Crucifers

Cabbage Yellows, *Fusarium oxysporum f. conglutinans*. O. S. R.: Commercial varieties of cabbage Wisconsin Ballhead and Wisconsin Hollander and selections from a susceptible variety Danish Ballhead. P. S. R.: Preceding varieties and numerous commercial cabbage varieties now in use. Nine varieties resistant to type A have been released. Inheritance: Type A, found in Wisconsin Ballhead, is monogenic dominant; type B, found in Wisconsin Hollander, is polygenic and becomes unstable when the soil temperature is unusually high.


Mosaic Virus. O. S. R.: Commercial varieties of cabbage. P. S. R.: Improved All Seasons cabbage. Inheritance: Resistance to the mottle phase is incompletely dominant polygenic, but controlled by relatively few genes. Resistance to the chlorosis symptom, incited by the B virus, also is incom-
Completely dominant and appears to be inherited quantitatively. Resistance to mottling seems to be independent of resistance to the chlorosis symptom.

Cucumber


Downy mildew, *Pseudoperonospora cubensis*. O. S. R.: Chinese Long, which is used in South Carolina and Puerto Rico, and Bangalore, an Indian variety that is used in Louisiana. P. S. R.: Puerto Rico Nos. 39 and 40, Palmetto, Santee, and Surecrop. Inheritance: Not definite. There is some segregation for resistance in the F₂ but no definite ratio. Resistant plants are tolerant but show some infection late in season. They will produce a crop where susceptible varieties fail.


Cucumber mosaic, *Marmor cucumeris*. O. S. R.: Chinese Long and Tokyo Long Green have tolerance only. P. S. R.: Pickling varieties Ohio 31, Ohio MR-17, Yorkstate Pickling and slicing varieties Niagara, Surecrop, Burpee Hybrid, Puerto Rico 10, and Puerto Rico 17. Inheritance: Shiffriss et al. state that three complementary genes apparently control the appearance or nonappearance of mottling in the cotyledon stage, the genetic ratio in the F₂ being 27 nonchlorotic to 37 chlorotic. The ratio of 27 : 37 is constantly changing in the true leaf stage. They state: "At this point several gene modifiers also take part in the genetical control of virus symptoms. Thus, the frequency of symptomless plants is very low."

Lettuce

Downy mildew, *Bremia lactucae*. O. S. R.: There are several commercial varieties each resistant to single biotypes of the fungus but none resistant to all biotypes. P. S. R.: Some of the Imperial varieties. Inheritance: Resistance is a monogenic dominant.


Lima bean


Muskmelons


SOME SOURCES OF RESISTANCE IN CROP PLANTS


**Onion**

Black Mold, *Aspergillus niger*. P. S. R.: White varieties, such as Southport White Globe and White Portugal, are resistant. Inheritance: Resistance is perfectly correlated with dry scale color. See statement under smudge regarding inheritance of dry scale color.


Purple Blotch, *Alternaria porri*. P. S. R.: Varieties, such as Yellow Globe Danvers and Red Creole, that have a covering of wax or "bloom" on the foliage are more resistant than varieties with a somewhat glossy foliage such as Sweet Spanish. Inheritance: Resistance is correlated with waxy (nonglossy) foliage. Waxy type of foliage dominant; probably monogenic.

Smudge, *Colletotrichum circinans*. P. S. R.: Red, yellow, and brown varieties, such as Southport Red Globe, Yellow Globe Danvers, and Australian Brown, are highly resistant. Inheritance: Resistance is perfectly correlated with dry scale color. Three pairs of genes are involved in the development of red, yellow, and white bulb color: C-c, a basic color factor, the dominant C gene being necessary for the development of any pigment, consequently all cc plants produce white bulbs; R-r, in the presence of C, the dominant R gene is responsible for the production of red pigment—its allele r is responsible for yellow; I-i, an inhibiting factor I is partially dominant over i—all II plants produce white bulbs.

Smut, *Urocystis cepulae*. P. S. R.: *Allium fistulosum*. Inheritance: In species crosses between *A. fistulosum* and *A. cepa* the F₁ is intermediate in resistance but sterile. A fertile amphidiploid, Beltsville Bunching, has considerable resistance.

Yellow Dwarf, *Marmor cepae*. P. S. R.: *Allium fistulosum*. Nebuka and Beltsville Bunching are immune from all strains of yellow dwarf tested. Lines immune from the common strains of yellow dwarf are Burrell’s Sweet Spanish, Colorado No. 6, Utah Sweet Spanish, White Sweet Spanish, Yellow Sweet Spanish, Crystal Grano, Early Grano, Early Yellow Babosa, White Babosa, Crystal Wax, Lord Howe Island, San Joaquin, and Yellow Bermuda. Inheritance: Undetermined.
**Pea**


**Pepper (Capsicum annuum)**

**Bacterial spot, Xanthomonas vesicatoria.** O. S. R.: Commercial varieties Waltham Beauty, Oshkosh, Sunnybrook, Squash, Harris Early Giant (some strains only), Wonder (some strains only), Harris Earliest (some strains only), Cayenne (selections), Santaka (selections). P. S. R.: Those listed under O. S. R. Inheritance: Both monofactorial dominant resistance gene and multiple factors are suggested. There are no clear-cut data.

**Bacterial wilt, Pseudomonas solanacearum.** O. S. R.: Ornamental variety, grown locally on island of Oahu, Hawaii, is highly resistant but not immune. P. S. R.: Ornamental variety only. Inheritance: Undetermined.


**Southern blight, Sclerotium rolfsii.** O. S. R.: *Capsicum frutescens* var. Tabasco is highly resistant; *C. annuum* var. Santaka is moderately resistant. P. S. R.: Varieties Tabasco and Santaka. Resistance is being incorporated into commercial varieties, primarily Bell and Pimiento types. Inheritance: Undetermined.

**Tobacco etch virus, Marmor erodens.** O. S. R.: Selections from Elephant Trunk x World Beater; Red Cherry, tolerant; P. E. I. 159241 highly resistant, possibly immune. P. S. R.: Varieties listed above, and resistance is being incorporated into commercial varieties, mainly Bell and Pimiento types. Inheritance: Undetermined.

**Wilt, Fusarium annuum.** O. S. R.: A local variety in New Mexico and Mexican and Peruvian varieties. P. S. R.: Chili No. 9 and College No. 6 were developed by the New Mexico Agricultural Experiment Station, and the varieties Cristal, Nora de Murcia, and Cacho de Cabra were developed in Peru. Inheritance: Undetermined.


**Hawaiian pepper virus (identity unknown; distinct from tobacco mosaic).** O. S. R.: Hawaiian variety Waialau highly resistant; Red Chili, Small Chili, and Tabasco are tolerant. P. S. R.: Varieties listed under O. S. R. Inheritance: Unknown; probably multiple factor.

**Puerto Rico mosaic virus (identity uncertain; possibly related to potato mild mosaic, distinct from tobacco**
**SOME SOURCES OF RESISTANCE IN CROP PLANTS**


**POTATOES**


**RING ROT, Corynebacterium sepedonicum.** O. S. R.: President, Friso, Teton, and United States Department of Agriculture seedlings 46952 and 055. P. S. R.: President, Furore, Teton, Saranac, Seedling 46952, and a number of seedling varieties related to these. Inheritance: Unknown. Five resistant varieties selfed; 55.4 to 85.0 percent of seedlings resistant.

**COMMON SCAB, Streptomyces scabies.** O. S. R.: European varieties, Jubel, Arnica, Hindenburg, Rheingold, Ackersegen, and Ostragis. P. S. R.: Preceding varieties and American varieties, Ontario, Menominee, Seneca, Cayuga, Yampa, Cherokee, and related seedling varieties; also wild species Solanum commersonii, S. chacoense, S. caldasii var. glabrescens and S. jamesii. Inheritance: Tetrasomic. There is one gene difference in some crosses; apparently more than one in others. Degree of resistance depends on dosage of resistance genes.

**LATE BLIGHT, Phytophthora infestans.** O. S. R.: Solanum demissum immune from all known races. S. andreanum, S. ajuscoense, S. henryi, S. antipovichii, S. milani, S. polyadenium, S. vallis-mexici, S. verrucosum probably immune. W varieties from Germany, probably related to S. demissum, are resistant to field races. P. S. R.: Original sources. There is immunity from certain races in Essex, Ashworth, Placid, and seedling varieties related to Solanum demissum and Kennebec, Cherokee, and other named and numbered varieties descended from German W varieties. Inheritance: Tetrasomic polygenic, immunity dominant. Three, four, or more genes combined to produce immunity to all known races. Number of genes is determined by the reaction of different seedlings to different physiologic races of the organism; mode of inheritance of individual genes determined by ratios found in selfed lines.


**WART, Synchytrium endobioticum.** O. S. R.: Snowdrop, Great Scott, Jubel, Hindenburg, and other European varieties, and the American varieties Green Mountain, Irish Cobbler, Triumph, Spaulding Rose, and Burbank. P. S. R.: In at least 80 European varieties and in Green Mountain, Irish Cobbler, Triumph, Spaulding Rose, Burbank, Katahdin, Sequoia, Pawnee, Ontario, Kennebec, Calrose, Mohawk, Chisago, Mesaba, and a number of seedling varieties. Inheritance: Tetrasomic. One gene difference in some crosses and more than one in others. Dominant gene X giving immunity even in simplex. Genes Y and Z complementary conditioning immunity when both present even in simplex.

**APHID INJURY.** O. S. R.: Segregates


**Leaf Roll. O. S. R.:** Degree of resistance exists in Houma, Katahdin, Triumf, Jubel, Flava, Imperia, Kepplestone Kidney, and Aquila. No varieties are immune. Immunity probably in *Solanum chacoense* and *S. andigenum*; tolerance in *S. polyadenium.* P. S. R.: Preceding varieties and species and in the United States Department of Agriculture seedlings X 927–3, X 1276–185, B 24–58, B 579–3, and other related seedlings. Some are more resistant than original varieties. Inheritance: Tetrasomic. Probably several genes. Katahdin and Houma probably simplex for one gene; X 1276–185 probably duplex.


**Virus X (latent mosaic). O. S. R.:** United States Department of Agriculture seedling 41956. P. S. R.: Seedling 41956 and seedling varieties related to seedling 41956 and *Solanum acaule.* Inheritance: Tetrasomic. Two complementary genes, immunity dominant. Seedling 41956 heterozygous; some plants of *S. acaule* probably homozygous; others heterozygous.


**Spinach**

**Blue Mold, Peronospora effusa. O. S. R.:** United States Department of Agriculture collection, P. E. I. 140467, made in Iran in 1940. P. S. R.: Commercial types are now being developed. Inheritance: Resistance is a monogenic dominant.

**Fusarium Wilt, Fusarium oxysporum spinaciae. O. S. R.:** Commercial Virginia Savoy. P. S. R.: Resistant selection of Virginia Savoy was developed by the Virginia Truck Experiment Station. Inheritance: Not determined.


**Sweetpotato**

**Stem Rot (wilt), Fusarium hyperoxysporum and F. oxysporum f. batatas. O. S. R.:** Selections from open-
pollinated seedlings of Cuban variety American; P. E. I. 153655, introduced from Tinian Island in 1946; Triumph, a white-flesh American variety; and Japanese white-flesh varieties Norin No. 2, Norin No. 3, Taihaku Saitama No. 1. P. S. R.: Goldrush and numerous seedling selections now being developed. Inheritance: Multiple factor.

**Tomato**


**Late Blight**, Phytophthora infestans. O. S. R.: Low-level resistance in several wilt types of L. esculentum, i. e., P. E. I. 134208 from India. P. S. R.: Low-level resistance in Garden State and Southland. Inheritance: Two small-fruited tomato types used as ornamentals and designated as P₁ and P₃ were observed to have a high degree of resistance in southern Florida. Inheritance segregation ratios in crosses made with cultivated varieties indicated that resistance was due to one main factor and one or more modifying factors. P₃ stocks uniformly resistant at Homestead, Fla., were not resistant in the high valleys of North Carolina or at Huttonsville, W. Va. The reason for the difference has not been determined.


**Curly Top**, Ruga verrucosans. O. S. R.: L. peruvianum var. dentatum; P. E. I. 128660, collected in Tacna, Peru, 1938; L. chilense; L. pisiisi; P. E. I. 127829, collected between San Juan and Magdalena, Peru, 1938; L. glandulosum; P. E. I. 126440, collected between Yangos and Canta, Peru, 1938; and Red Peach. P. S. R.: Original introductions and commercial types now being developed. Inheritance: Not determined.


**Root Knot**, Meloidogyne incognita.
O. S. R.: *L. peruvianum*. P. S. R.: *L. peruvianum* and commercial types being developed. Inheritance: Resistance partially dominant, apparently due to one or two major dominant genes; modifiers or additive action genes possible.

**S**potted Wilt, 3 viruses. O. S. R.: *L. pimpinellifolium, L. peruvianum, and California BC 10*. P. S. R.: Pearl Harbor, Manzana, German Sugar, Oahu, Lanai, Hawaii, Maui, Molokai, Kauai, and Nauhu. The last 7 of these varieties probably inherited their resistance from German Sugar and *L. peruvianum*. Inheritance: Resistance from Pearl Harbor to Hawaii strain of spotted wilt is a monogenic dominant.

**W**atermelon


**F**redrick J. Stevenson has been employed since 1930 as a geneticist in charge of the national potato-breeding program of the Department of Agriculture. From 1919 to 1925, at the State College of Washington, he worked with breeding for resistance to bunt in wheat and smut in oats. From 1925 to 1930, at the University of Minnesota, he cooperated with others in breeding for resistance to rusts in wheat and oats and Helminthosporium in barley.

**H**enry A. Jones has been with the Department of Agriculture since 1936. Previously he was head of the division of truck crops at the University of California. His chief investigations have had to do with the development of hybrid onions and disease resistance in onions. He is a graduate of the University of Nebraska and the University of Chicago, and in 1952 received an honor-