Transmission and Control of Plant Diseases in Propagules

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In the final analysis, the two sources of plant pathogens are previously infected plants and the soil, including the water and organic matter associated with it. A complete disease control program for soilborne pathogens, therefore, emphasizes planting clean, pathogen-free propagules in soil as free of pathogens as is economically feasible, and reinforcing these conditions by sanitation, ecological manipulation, and biological control. The carryover of a plant pathogen in soil is essentially a holding mechanism; its transmission in seeds, bulbs, cuttings, and other propagules is primarily disseminating, but is secondarily a holding mechanism. The propagules introduce the pathogen, the soil maintains it.

Significance of Propagule Transmission

Propagule transmission of plant pathogens is important because it efficiently transfers the pathogen both spatially (geographical spread) and temporally (carryover from season to season). In addition, propagules are an effective means for selection and spread of host-specific strains of the pathogen, and for random distribution of them as infection centers in a planting.

Growing a given host or cultivar continuously in a field where seeds or other propagules are produced favors the increase of its pathogens and the probability of their infecting the propagules. Strains of **Rhizoctonia solani** virulent to the crop infect bulbs, corms, or divisions grown in the soil. Cuttings may be contaminated by splashed soil particles containing the pathogen. Seed may be infected by the pathogens growing through canvas sheets on which seed is piled in the field, or by otherwise coming in contact with the soil. **Rhizoctonia solani** has many strains differing in features such as host range and environmental response. While **R. solani** may be present in many soils, virulent strains for a specific plant are not common and should not be introduced into new locations. Once introduced into field soil, most soil-borne pathogenic fungi are economically difficult or impossible to eradicate.

Although only a low percentage of propagules is ordinarily infected with a pathogen, that percentage is important because it serves as an infection center. The rate of increase of pathogens is so great that an epidemic often seems to "suddenly appear." A single sclerotium of the cottony rot fungus **[Sclerotinia sclerotiorum]** may produce several tiny, cup-shaped structures that may form up to 300,000,000 spores. A single leaf spot of celery late blight **[Septoria apiicola]** may produce more than 200,000 spores. Snapdragon rust **[Puccinia antirrhini]** may increase from a single pustule in a shipment of 10,000 plants to an average of 4,600 pustules on each plant 90 days later. Epidemics, like fires, are best stopped while they are small.

Among the many benefits from the elimination of disease in a crop by planting clean stock in clean soil are increased growth potential, environmental tolerance of the crop, and better evaluation of cultural practices. Almost anyone in the plant business will agree that pathogen-free propagules are desirable, but there are differences of opinion on the price one can justifiably pay for them and on the best ways to use them. These opinions can change with time. For example, inexperienced growers often buy a small number of pathogen-free cuttings from a commercial propagator and use them as parent stock for propagation for several years; later they use them for only one year, and finally let the propagator produce the cuttings while they grow the crop.

Sometimes growers minimize the importance of pathogen-free stock because the pathogens are thought to be already present. Thus, **Rhizoctonia solani** is said to be "everywhere," despite the known occurrence of many different strains, none of which is everywhere. There is no such thing as a safe soil-infesting pathogen.

A plant propagator has an obligation to produce stock free of disease organisms, and to sell planting media also free of pathogens. Propagators are sometimes unaware of disease in their propagules, or they may think that, since perfection is unattainable, a fairly clean stock is good enough. In any case, the grower should let the propagator know if any infected stock is received. In the democratic process of the business world, the grower who accepts diseased stock without protest is derelict of his duty in the system.

If a grower propagates stock himself, this procedure should be isolated carefully from the production operations of the business and should be protected from possible pathogen contamination. The essence of this mother-block principle is that it is easier to maintain an isolated small planting than a large one under strict sanitation. It is also a wise precaution to have an isolation house in which plants of uncertain health are kept until they are shown to be free of pathogens.

CONTROL PROCEDURES

Cuttings and Lining-out Stock

For most of the important crops today (chrysanthemum, carnation, poinsettia, geranium, azalea, and some foliage plants), propagators produce pathogen-free cuttings. However, for some plants it is necessary for the grower to propagate his own stock. A number of generalized procedures will greatly reduce the risk of producing infected plants. Cuttings should be taken from the tops of plants grown without overhead watering or splashing soil, to minimize contamination by soil. For weak-stemmed or trailing plants such as ivy, the shoots should be grown up on frames away from the soil. Cuttings should be taken only from healthy plants grown without overhead irrigation. The use of cultured cuttings freed chrysanthemum, rose, carnation, and geranium of disease organisms, but this method has now largely been replaced by apical meristem culture. These latter two techniques are used mostly by commercial propagators, because special laboratories and trained personnel are required.

Heat treatment of cuttings or canes will eradicate pathogens but may be injurious to the material. Propagules to be treated should be as clean and healthy as possible and should be in a hardened condition. For example, foliage plants grown without nitrogen fertilizer and with minimal watering for 3-6 months are much more heat-tolerant than succulent, actively growing stems. Material should be cleaned of dead leaves and dirt and should have as few wounds as possible. Dieffenbachia canes are therefore treated in 2-foot pieces in hot water at 51.7°C (125°F) for 30 minutes, and later divided into single-bud pieces. Heat treatment is with hot water or aerated steam. If aerated steam is used, the propagules must be placed loosely in the container and the interspaces filled with dry, coarse sand to insure uniform treatment. Timing must be precise, and the thermometers used must be accurate **in the treatment range**. Prompt cooling following treatment is essential. Following hot-water treatment, the material is dipped in cold water; with aerated steam, the steam is shut off and the air flow cools by evaporation. Details of methods are given in Baker (1957, 1962, 1969, 1972).

Small plants of **Aloe variegata** may be freed of **Pythium ultimum** by hot-water treatment at 46.1°C (115°F) for 20-40 minutes, depending on the size of the plant (Baker and Cummings, 1943).

Bulbs and Corms

Thermotherapy has been effectively applied against several pathogens transmitted with bulbous propagules. Gladiolus cormels are commercially treated in hot water at 57.8° - 58.9°C (136° - 138°F) for 30 minutes to free them of internally borne **Fusarium oxysporum** f. sp. **gladioli** (cause of yellows) or **Stromatinia gladioli** (cause of dry rot). Although the margin between the thermal death point of cormel and pathogen is small, manipulation of some factors may so increase it that treatment is made commercially practical. Cormels are more heat tolerant than corms and are therefore used. The level of dormancy of cormels strongly affects their heat tolerance; nondormant cormels are severely injured. There also are differences in dormancy between varieties in a given planting. The use of 2, 3, 5-triphenyltetrazolium chloride on longitudinally split cormels is an effective method for estimating their dormancy; the more intense the red color, the less the dormancy. It has been found that cormels produced in warm relatively dry soil are more tolerant of heat treatment than are those grown in cooler, moister soil. Thus cormels grown in Washington or New York do not stand heat treatment well, but those grown in southern California or Florida do (Roistacher **et al.**, 1957).

Rhizomes of calla lillies may be freed of **Phytophthora richardiae** by hot-water treatment at 50°C (122°F) for 1 hour. The rhizomes to be treated should be mature and dried (Dimock and Baker, 1944).

Tubers of tuberous begonias may be freed of **Pythium** sp. by treatment in hot water at 44.4°C (112°F) for 30 minutes, or by aerated steam at 46.1°C (115°F) for 45 minutes without injury to dormant tubers (Raabe and Baker, 1972).

Seeds

Seeds may be treated with chemicals or heat.

Protective chemical treatments with thiram, maneb, captan, chloranil, or dichlone aim at preventing attack of the seed by soil microorganisms, but are of little or no value in preventing seed transmission of pathogens. **Eradicative chemical treatments** with thiabendazole, carboxin, benyomyl, or hexachlorobenzene may kill pathogens on the surface of the seed, between glumes and the seed, or in shallow infections of the seed coat. **Heat treatments** are used against pathogens so situated in the seeds as to be protected from chemicals. Hot water, aerated steam, and hot dry air have been used. Hot air may be used to free snapdragon seed of rust spores **[Puccinia antirrhini]**; treatment is at 46.1°C (115°F) for 1

hour. Seeds treated with hot water absorb much water, undergo severe leaching of soluble materials, require drying before storage or planting, and therefore sustain more injury than those treated by aerated steam. Treatments vary with pathogen and host in the range 40° - 57°C (120.2° - 152.6°F) for 30 minutes; cooling is by evaporation from air flow (with steam shut off) until seed reaches 31.7°C (90°F).

Any seed treatment decreases germination, particularly with seed of low vitality or more than one year old. This physiological injury may be repaired and germination restored if metabolism can proceed without cell enlargement or radicle emergence. Following heat treatment such repair is achieved if seed is held in polyethylene glycol 6000 (PEG). The germination of tomato seed, for example, dropped from 99% to 54%, but returned to 94% following PEG treatment. Combining aerated steam and PEG treatments thus offers a means of using temperatures sufficiently high to insure killing the pathogen with minimal seed injury (Baker, 1980).

Following any heat treatment, seed should be treated with a mild protective fungicide.

References

Baker, K.F. (ed.) 1957. The U.C. System for Producing Healthy Container-Grown Plants. **Calif. Agric. Exp. Sta. Manual** 23:1-332.

Baker, K.F. 1962. Principles of Heat Treatment of Soil and Planting Material. **Jour. Austral. Inst. Agric. Sci.** 28: 118-126.

Baker, K.F. 1962. Thermotherapy of Planting Material. **Phytopathology** 52: 1244-1255.

Baker, K.F. 1969. Aerated Steam Treatment of Seed for Disease Control **Hort. Res.** 9: 59-73.

Baker, K.F. 1972. Seed Pathology. **In Seed Biology** (ed. T. Kozlowski) vol. 2: 317-416. Academic Press, New York. 447 pp.

Baker, K.F. 1980. Pathology of Flower Seeds. **Seed Sci. Technol.** 8 (in press).

Baker, K.F., and K. Cummings. 1943. Control of Pythium Root Rot of **Aloe variegata** by Hot-water Treatment. **Phytopathology** 33:736-738.

Dimock, A.W., and K.F. Baker. 1944. Hot-water Treatment for Control of Phytophtora Root Rot of Calla. **Phytopathology** 34:979-981.

Raabe, R.D., and K.F. Baker. 1972. Heat Therapy for Control of Pythium Storage Rot of Begonia Tubers. **Acta Hort.** 1(23): 213-218.

Roistacher, C.N., K.F. Baker, and J.G. Bald. 1957. Hot-water Treatment of Gladiolus Cormels for the Eradication of **Fusarium oxysporum f. gladioli. Hilgardia** 26:659-684.

Roistacher, C.N., J.G. Bald, and K.F. Baker. 1957. 2, 3, 5- Triphenyltetrazolium Chloride as an Indication of Germinability and Dormancy of Gladiolus Cormels. **Hilgardia** 26:685-704.

Based on a talk presented at the Ornamentals Northwest Seminars in Portland, Oregon.