**Use of Pathogen-Free Propagating Material**

When a pathogen is excluded from the propagating material (seed, tubers, bulbs, nursery stock) of a host, it is often possible to grow the host free of that pathogen for the rest of its life. Examples are woody plants affected by nonvectored viruses. In most crops, if the host can be grown free of the pathogen for a considerable period of its early life, during which the plant can attain normal growth, it can then produce a fairly good yield despite a potential later infection. Examples are crops affected by vectored viruses and phytoplasmas and by fungal, bacterial, and nematode pathogens. There is absolutely no question that every host plant and every crop grow better and produce a greater yield if the starting propagating material is free of pathogens, or at least free of the most important pathogens. For this reason, every effort should be made to obtain and use pathogen-free seed or nursery stock, even if the cost is considerably greater than for propagating material of unknown pathogen content. All types of pathogens can be carried in or on propagating material. True seed, however, is invaded by relatively few pathogens, although several may contaminate its surface. Seed may carry internally one of a few fungi (such as those causing anthracnoses and smuts), certain bacteria causing bacterial wilts, spots, and blights, and one of several viruses (tobacco ring spot in soybean, bean common mosaic, lettuce mosaic, barley stripe mosaic, squash mosaic, and prunus necrotic ring spot). However, vegetatively propagated material such as buds, grafts, rootstocks, tubers, bulbs, corms, cuttings, and rhizomes are expected to carry internally almost every virus, viroid, phytoplasma, protozoon, and vascular fungus or bacterium present systemically in the mother plant, in addition to any fungi, bacteria, and nematodes that may be carried on these organs externally. Some nematodes may also be carried internally in some belowground propagating organs (tubers, bulbs, corms, and rhizomes) and in or on the roots of nursery stock.

**Pathogen-Free Seed**

Seed that is free of fungal, bacterial, and some viral pathogens is usually obtained by growing the crop and producing the seed in (1) an area free of or isolated from the pathogen, (2) an area not suitable for the pathogen (e.g., the arid western regions of the United States where bean seed is produced usually free of anthracnose and bacterial blights), or (3) an area not suitable for the vector of the pathogen (e.g., the northern or high altitude fields where aphids, the vectors of many viruses, are absent or rare).

It is very important, and with seed-transmitted and aphid-borne viruses it is indispensable, that seed be essentially free of the pathogen, especially virus. Because, if carried in the seed, the pathogen will be present in the field at the beginning of the growth season, and even a small proportion of infected seeds is sufficient to provide enough inoculum to spread and infect many plants early, thus causing severe losses. It has been shown, for example, that to control lettuce mosaic virus, only seed lots that contain less than one infected seed per 30,000 lettuce seeds must be used. For this purpose, seed companies have their lettuce seed tested for lettuce mosaic virus every year. In past years, seeds were tested (indexed) by growing out hundreds of thousands of lettuce seedlings in insect-proof greenhouses, observing them over several weeks for lettuce mosaic symptoms, and attempting to transmit the virus from suspect plants to healthy plants. Later, indexing was done by inoculating a local lesion indicator plant (in this case *Chenopodium quinoa*) with sap from ground samples of groups of seeds and observing it for virus symptoms.

Testing seed for fungal and bacterial pathogens is done by symptomatology, microscopically, and by culturing the pathogen on general or selective nutrient media. For detection and identification of bacteria, serological tests are also being used with increasing frequency and accuracy

Hot water treatments are used to free cabbage seed from Xanthomonas campestris pv. campestris, the cause of black rot of cabbage, and from Leptosphaeria maculans (Phoma lingam), the cause of black leg of cabbage. Also, hot water treatment frees seed of wheat and other cereals from Ustilago sp., the cause of loose smuts of cereals.

**Pathogen-Free Vegetative Propagating Materials**

To ensure continuous production of pathogen-free buds, grafts, cuttings, rootstocks, and runners of trees, vines, and other perennials, the mother plant is indexed for the particular pathogen at regular (1- to 2-year) intervals. Indexing is usually done by taking grafts or sap from the plant and inoculating susceptible indicator plants to observe possible symptom development.

The new plants must be grown in pathogen- and vector-free soil and then be protected from airborne vectors of the pathogen if they are to remain free of the pathogen for a considerable time.

With some crops, such as carnation and chrysanthemum, greenhouse growers need cuttings free of the vascular wilt-causing fungi Fusarium and Verticillium each time, but it is almost impossible to keep these two fungi from the production beds. It was noted early, however, that short cuttings taken from the tips of rapidly growing shoots were usually free of either of these fungi, and this became a common practice to control these diseases.