"Nursery Propagation by Hardwood Cuttings" Question-Answer Period

No recording.

Biology and Management of Crown Gall Disease in the Nursery

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Crown gall disease occurs on over 390 genera of plants (Bradbury, 1986). It is most significant on plants grown for the nursery trade because galled plants are culled and discarded. Annual losses can run in the millions of dollars (Kennedy, 1980). The disease is particularly damaging to plants that become infected the first year after out-planting. Severely galled young plants are weakened, stunted, unproductive, and occasionally die. Contradictions abound, however, regarding the injurious effects of crown gall. Regardless, current nursery practices of culling galled plants is highly recommended as a means of providing clean planting stock.

Crown gall is a tumor disease of plants caused primarily by three pathogenic species of *Agrobacterium: A. tumefaciens, A. rhizogenes*, and *A. vitis* (Bouzar, 1994). Although this "new" classification is more correct than earlier classifications, it is confusing due to historical usage of *A. tumefaciens* to designate pathogens and *A. radiobacter* to designate nonpathogens. For sake of clarity, I will use the descriptors "pathogenic" and "nonpathogenic" *Agrobacterium* throughout this paper, with the exception of *A. vitis,* the crown gall pathogen of grape vines.

Emphasis of this paper is on management practices to reduce the incidence of disease to an economically tolerable level. Rarely will 100% control of the disease be achieved by any single method due to the interaction of multiple environmental factors, genetic variability among the pathogenic strains, host susceptibility, and cultural practices.

BIOLOGY AND ECOLOGY

Learning basic elements about the biology of *Agrobacterium* and its disease cycle is important to understanding why various management procedures are effective, and, conversely, why some methods fail. Briefly, pathogenic strains of *Agrobacterium* are considered present in most agricultural soils or on infested plants. The pathogen is disseminated by splashing rain, irrigation water, drainage water, tools, wind, insects, and plant parts used for propagation. Plant wounds are required for infection. Wounds occur during pruning and cultivation, natural emergence of lateral roots, frost injury, and insect and nematode feeding. The pathogen colonizes the wound and transfers part of its DNA into the chromosome of a plant cell. This event initiates gall development. Small galls appear in 10 to 14 days at temperatures above 72F; infection is inhibited above 92 to 97F and below 50F. Latent infections occur (Moore, 1976), but long latent infections are not common in our experience.

The gall is a rich source of nutrients for the *Agrobacterium* which proliferate and escape the gall to begin the infection cycle anew or survive as nonparasitic epiphytes on the surfaces of host and nonhost plants, particularly roots. Pathogenic *Agrobacterium* also survive saprophytically as endophytes in the xylem tissues of some plants (e.g. grape vines) and reportedly up to 2 years in soil. Lelliott (1971) observed that crown gall occurrence in apple rootstocks beds in England could not be related to soil type (e.g., type of loam or silt loam), kind of bed, age of bed, nor soil pH.

Diversity: There is wide diversity among *Agrobacterium* isolates from different plant hosts, planting sites, and even the same gall. Failure to recognize this diversity leads to unwarranted assumptions and generalizations, whereas recognition of the diversity can aid in making disease management decisions.

DISEASE MANAGEMENT

Prevention: Think prevention! Avoid exposing plants to pathogenic *Agrobacterium* at all stages of plant production. Once infection has occurred, there is little that can be done to stop the disease. Factors important to prevention include the following.

Planting Stock: Pathogen-free plants grown in uninfested soil do not develop crown gall, which emphasizes the importance of planting clean propagating material to clean soil. Dispersal of agrobacteria to other geographical areas is readily accomplished through shipment of diseased and infested planting materials. However, it is difficult to prove whether infectious inoculum was present in the soil at planting, introduced into the planting site by water, or carried on or in the transplant propagule.

Cultural Practices: Suppliers and growers alike should use good sanitation and cultural practices as deterrents to crown gall disease. Upon harvest, discard all nursery stock showing gall symptoms to avoid contamination of healthy plants. (Despite careful sorting and culling of diseased plants, latent infections and symptomless plant carriers of pathogenic *Agrobacterium* go undetected. Unfortunately, we have no practical way to detect latent infections or symptomless plant carriers.) Surface sterilize benches and tools used in propagation and storage. Keep graft and bud unions above the soil line. Avoid: wounding plants during cultivation, use of high nitrogen and irrigation late in the season, and storing diseased plants with healthy plants. Irrigate with deep-well water or sanitized pond water.

Planting Sites: Previous cropping history can affect gall incidence. A general recommendation is to avoid planting sites where galled plants were grown within the last 4 to 5 years and rotate with nonhost crops such as grains. Avoid planting to heavy, poorly drained soils and those with nematode infestations or insect vectors.

Vectors: Nematodes (Dhanvantari et al., 1975; Vrain and Copeman, 1987), grubs and other chewing insects (Tawfik et al., 1983), and whiteflies (Zeidan and Czosnek, 1994) have been implicated in providing wounds and being passive carriers *of A. tumefaciens*. Nematode feeding also increased the susceptibility of resistant raspberry (*Rubus idaeus*) plants to *Agrobacterium* pathogens (Vrain and Copeman, 1987).

Disease Resistance: Although genetic resistance to crown gall is the ideal method of control, reports of plant resistance to crown gall are limited and variable.

Differential host susceptibility has been reported among grape and raspberry cultivars. In Britain, Malling Jewel was considerably more resistant than Malling Delight. Malling 7 is considered the most susceptible apple rootstock to crown gall in Italy and the Pacific Northwest, followed by *Malus* 'Jaune de Metz' (syn. Malling 9) and Malling 26. Malling 9, however, is reportedly the most susceptible rootstock in Switzerland. This variability is probably due to strains of the pathogen being better adapted to one nursery site than another. Because of this variability, use more than one pathogenic strain when screening plant selections for resistance to *Agrobacterium* pathogens.

Chemical controls are very limited. Traditional bactericides have included copper and streptomycin formulations. Neither of these groups have been particularly effective as preplant dips or sprays to control crown gall, especially on apple and pear rootstocks (Mirow, 1985). Terramycin as a preplanting treatment of apples and pears has given relatively good control of crown gall in Oregon and Washington tests, but it is not registered with EPA for commercial use (Canfield and Moore, 1992).

Soil fumigation with Vorlex was reportedly effective against some strains of *A. vitis* (Pu and Goodman, 1993), but not against crown gall pathogens of peach (Dhanvantari, 1975). Soil treatments with Metam-sodium and formaldehyde also failed to control crown gall (Utkhede and Smith, 1990). Methyl bromide has generally been ineffective against *Agrobacterium* (Cooksey and Moore, unpublished), while soil fumigation with a variety of fumigants reportedly increased the incidence of crown gall on mazzard cherry seedlings (Deep and Young, 1965).

Physical Heating: Physical heating of root-pruned, dormant *Prunus* rootstocks to encourage wound healing greatly reduced the incidence of crown gall (Moore and Allen, 1986). Careful heating of grape cuttings reduced populations of *A. vitis* in vascular fluids of grape vine cuttings (Ophel et al., 1990).

Biological Control: *Agrobacterium radiobacter* K84 has given excellent control of crown gall disease on a variety of host plants, particularly *Prunus* spp., but it is generally ineffective against crown gall disease of apple and pear rootstocks (Utkhede and Smith, 1990) and *A. vitis* on grape vines. Best control is observed when pathogenic strains are sensitive to K84. Strain K1026, an improved genetically engineered mutant of K84, is safer than K84 and is poised to enter the commercial market (Vicedo et al., 1993).

Microorganisms other than K84 have been investigated for biocontrol of crown gall. These include fungi, other *Agrobacterium* and non-*Agrobacterium* isolates (Cooksey and Moore, 1980; Pu and Goodman 1993). Utkhede's (1992) research with *B. subtilis* shows promise for biological control of crown gall on apple trees.

An integrated pest management strategy has been in test at Oregon State University for the past few years to investigate the effect, individually and in combination, of soil solarization, cover crops, and Metam-sodium fumigation on survival of *A. tumefaciens* and *A. rhizogenes, Pratylenchus penetrans, Verticillium dahliae*, *Phytophthora cinnamomi*, and weed seeds in different-textured soils. Soil solarization eliminated or greatly reduced the population of pathogenic *Agrobacterium* in sandy loam and clay loam soils, respectively (Raio, et al. 1996). No galls developed on mazzard cherry seedlings planted to solarized soils.

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