CROWN GALL OF GRAPE: UNDERSTANDING THE DISEASE, PREVENTION AND MANAGEMENT

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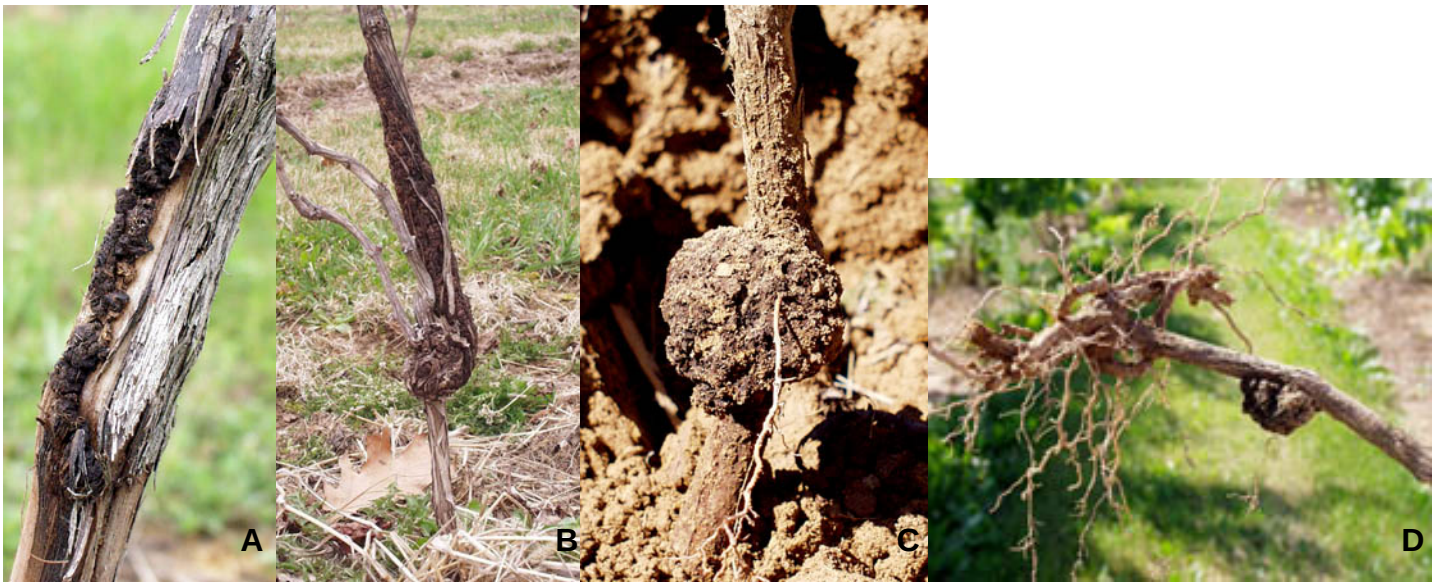
INTRODUCTION

Crown gall on grape, caused by the bacterium *Agrobacterium vitis*, occurs throughout the world where grapes are grown. In Pennsylvania and New York, crown gall can lead to vine decline and mortality in vineyards (Stewart & Wenner, 2004). Grapevines grown in areas subject to freezing winter temperatures are especially vulnerable to crown gall because freeze injuries provide a wound where the disease can initiate.

The crown gall pathogen survives systemically within the grapevine and causes disease at wounded areas on the vine (Lehoczky, 1968). There are both tumorigenic and nontumorigenic strains of *A. vitis* found on grape (Burr et al, 1998). Tumorigenic strains are detected only in soils that have been used to grow grapes and can induce infected vines to develop large galls at, above, and/or below the soil line. Nontumorigenic strains can be found on the roots of wild vines and have not been associated with gall formation. Tumorigenic strains of *A. vitis* are initially introduced into new vineyard soils by planting infected nursery stock.

Studies have shown that *A. vitis* can survive in small pieces of dead grape debris remaining in the soil for at least 2 years after the removal or death of a vine (Burr et al 1995) while other researchers have found that grape roots may remain viable in the soil for at least 5 years after the removal of a vine (Raski et al, 1983). Vines that are free of crown gall can be infected when planted in soil with debris remaining from a vine that was infected with *A. vitis* (Burr et al, 1995). Therefore, the best way to prevent crown gall in the vineyard is to prevent the site from being contaminated with infected plants from the beginning.

Infected vines may remain symptomless until the vine is injured. Injury that leads to expression of crown gall can result from freezing, pruning, grafting, training vines, and from other mechanical devices employed in maintaining the vineyard. As the gall forms, the tissues that normally function to conduct water from the roots to the shoots and photosynthetic products from the leaves to the roots become highly disorganized and lose their ability to function. Large galls that girdle the vine result in significant vine decline, and may lead to vine death. If the gall is smaller and localized, the vine can survive with a reduced, but functional vascular system resulting in a reduction in vine vigor and productivity.



A. Crown gall at graft union and possible freeze injury site. B. Crown gall initiating at freeze injury. C & D. Crown gall on Cabernet Franc vine below the soil line.

SYMPTOMS

Newly formed galls are often first noticed in June-July and appear as pale-colored, fleshy, convoluted tissue immediately beneath the bark layer. Crown gall may develop on any freshly wounded, woody portion of the vine. It usually shows up low on the trunk, or at the graft union. Galls have been observed below the soil surface which can lead to underestimating the incidence of crown gall in a block of vines (Stewart & Wenner, 2004). *A. vitis* also causes areas of root necrosis on infected vines (Burr et al, 1987).

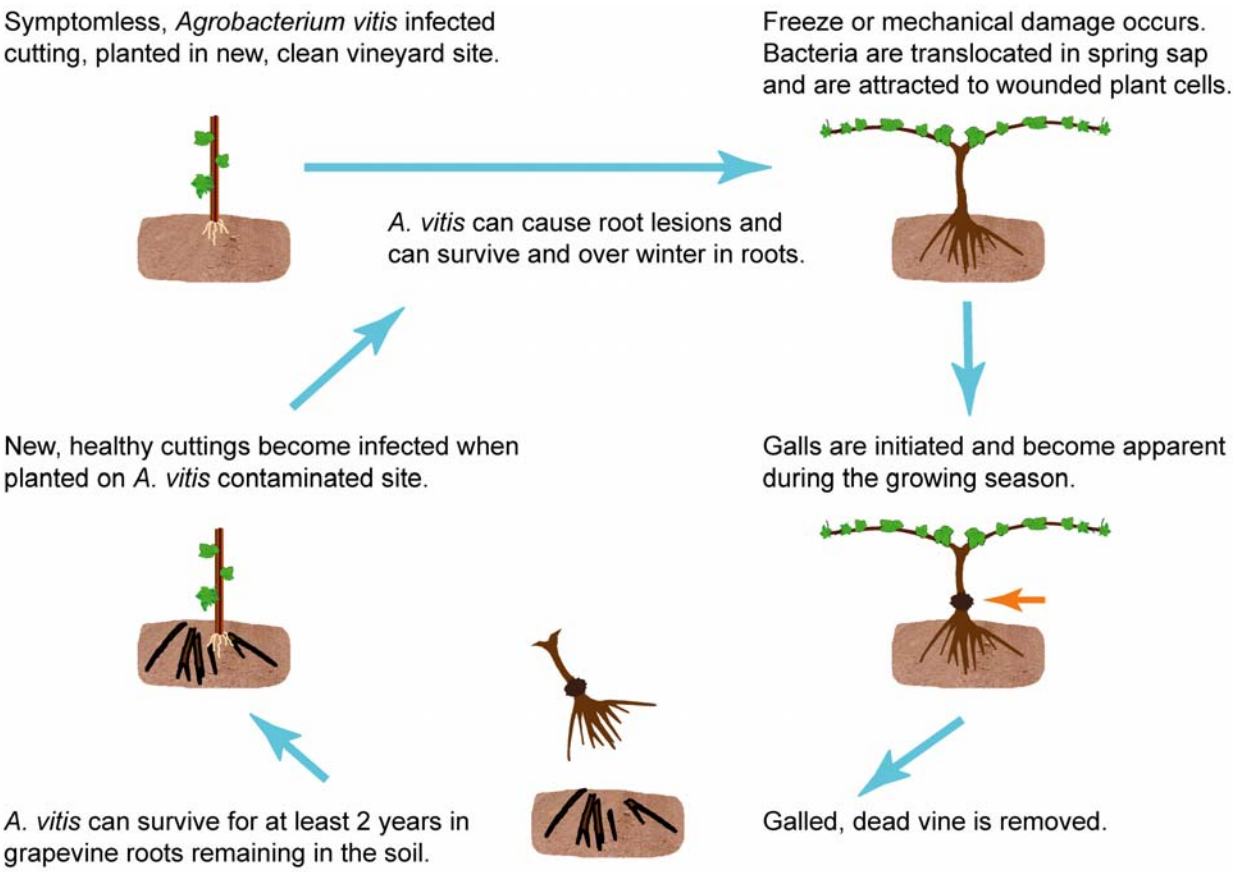


Fig 1. Illustration of how *Agrobacterium viti*s enters a vineyard in a symptomless, but infected vine, how the crown gall disease develops and can spread to new, uninfected replacement vines.

HOW *AGROBACTERIUM VITIS* CAUSES CROWN GALL

When a grapevine cell is wounded, it releases a compound that attracts *A. vitis* to the cell. The bacterium then transfers a piece of its DNA (called T-DNA) into the plant cell DNA (Figure 2). When integrated into the plant DNA, the bacterial T-DNA directs the cell to produce an overabundance of the plant hormones auxin and cytokinin which lead to the uncontrolled division and growth of the infected plant cells, resulting in gall formation. The T-DNA also instructs the infected plant cells to produce compounds called opines that serve as a carbon and nitrogen source for *A. vitis*, giving them an advantage over other bacteria.

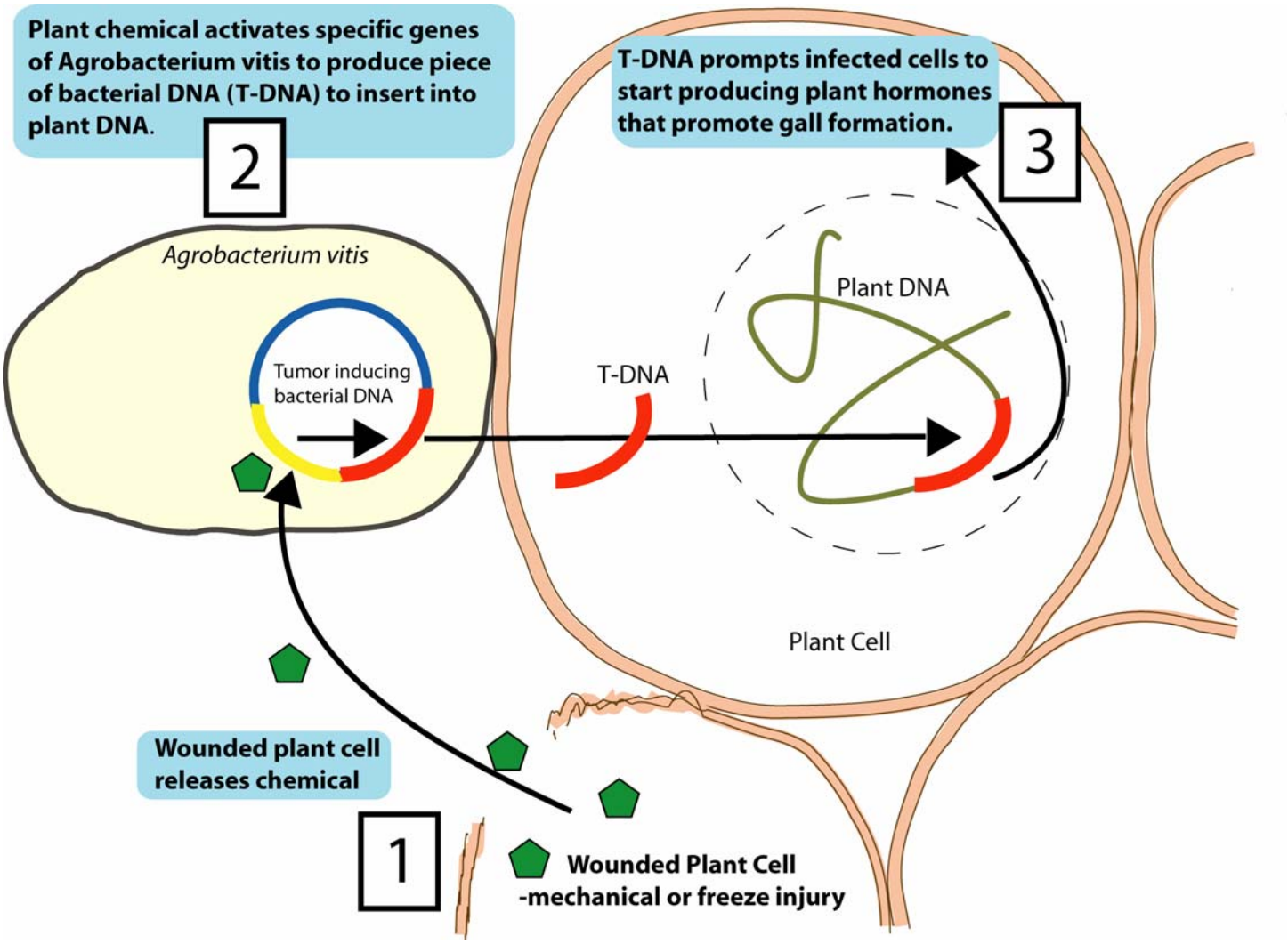


Fig 2. Illustration of *Agrobacterium viti*s transformation of grapevine plant cells leading to the formation of crown gall. **Step 1:** A plant cell that is wounded from mechanical or freeze releases a chemical which turns on certain genes in *A. vitis*. **Step 2:** The activated genes direct the bacteria to produce a piece of transfer DNA (called T-DNA) which will be transferred from the bacteria into the plant cell. **Step 3:** The T-DNA is incorporated into the DNA of the grapevine plant. The DNA serves as a "recipe" for the cell to make all components of the cell which make up all the parts of the plant. The inserted T-DNA directs the plant to produce the hormones auxin and cytokinin which cause the plant cells to grow and divide uncontrolled and rapidly (very similar to cancer). The crown gall is made up of this overgrowth of plant cells.

PREVENTION & MANAGEMENT STRATEGIES

The most important step in preventing crown gall is to avoid planting infected material in the vineyard. When choosing which grapes to grow, keep in mind that *Vitis vinifera* cultivars are especially susceptible to crown gall and phylloxera. One way to avoid problems with these diseases is to graft *V. vinifera* to resistant rootstocks. Studies have shown that some rootstocks such as 3309C, 101-14 Mgt, and Riparia Gloire that have been used for phylloxera resistance, may also provide resistance to crown gall (Burr et al, 1998, Sule & Burr, 1998). In one study, crown gall susceptible *Vitis vinifera* vines grafted on Gloire rootstocks were infected with *A. vitis*, and still developed symptoms after 3-4 years, but they were able to recover compared to non-grafted *V. vinifera* (Sule & Burr, 1998). In some instances the infected trunk had died, but a new trunk from below the gall survived without any galling. From that research, it was concluded that "rootstocks can greatly affect the severity of crown gall infection of grapevine" (Sule & Burr, 1998).

When choosing a vineyard site, avoid frost prone areas and wet, heavy soils to prevent freeze injury to potentially infected grapevines. Before planting, be sure to control soilborne nematodes. Studies have shown that the incidence of crown gall is higher on nematode infected vines (Sule et al, 1995). After planting, it is important to avoid external mechanical wounding of trunks and canes as well as freeze injury. Ways to avoid freeze injury include:

- Planting in sites which are not prone to cold winter temperatures and selecting cultivars suitable to the site. Do not plant cold sensitive *V. vinifera* cultivars in a frost prone area.
- Hilling-up young vines to protect graft unions and the lower trunk in young, own rooted vines.
- Balance pruning and not overcropping.
- Applying K2O (potash) instead of nitrogen fertilizers to improve vine cold resistance.
- Avoid vigorous late season growth so vines will harden off for winter.

Vines infected with crown gall that are not girdled, can often be pruned and retrained to regain productivity. Galled and girdled trunks can be removed and new trunksbrought up for training. Partially girdled trunks may outgrow the gall. Success of this process is determined by the susceptibility of the cultivar and the environmental conditions that trigger gall development. Successive generations of galls can form on a single vine resulting from freeze damage and other forms of mechanical damage to plant cells. When managing crown gall affected vines keep the following things in mind:

- Maintain two trunks on crown gall infected vines and be prepared to bring up new shoots for trunk renewal.
- Remove galled prunings from the vineyard and burn them if possible.
- When replacing vines killed by crown gall, remove the dead vine and as much of the root mass as possible because *A. vitis* can live for years on decaying roots.
- Copper compounds applied for downy mildew may help manage crown gall.

Top: Young grapevines removed due to crown gall. The crown gall pathogen can survive in the debris of roots, trunks and canes in the soil, so it is important to remove any *A. vitis* infected plant material from the vineyard and burn if possible. This may help to reduce levels of the pathogen in the soil and help prevent the infection of replants. **Bottom:** A vineyard that had a high mortalilty of vines due to crown gall. The cost of replanting, and loss of production and profit can be high for severly infected vineyards (see page 5).

Empty trellis in vineyard due to removal of vines with crown gall.

ECONOMIC IMPACT OF CROWN GALL

We have put together some hypothetical numbers and made a few assumptions to illustrate the economic impact of crown gall on a vineyard and winery operation. The numbers can vary widely, but the economic and psychological impact of crown gall on growers and wine makers is not to be underestimated.

Vineyard Management Costs

Cost of vines: $3.50 X 2 (orig. & replacement) = $ 7.00

Labor to plant $2.50 X 2 (orig. & replacement) = $ 5.00

Labor to train $3.00 X 6 years = $18.00

Cost per vine = $30.00

1/3 acre or approx. 200 vines replaced due to crown gall

200 X $30.00 = **$6,000**

Loss of Wine Sales

- 1 vine produces 10-15 lbs. grapes/year
- 1/3 acre (200 vines) = (approx.) 1 ton grapes
- 1 ton grapes = (approx.)750 bottles of wine

750 bottles wine X $9.00 = **$6700 lost in wine sales lost/year**

$6700 X 6 years = **$40,500 lost in wine sales over six years**

Potential economic loss in replant and wine sales over a six year period =$46,500

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