Graft compatibility of new scion-rootstock combinations

By Ute Albrecht, Bo Meyering, José Chaparro and Kim D. Bowman

Grafting is an ancient horticultural technique. There is evidence of citrus grafting in the Roman era dating back to the fifth century. In western Europe, grafting was regularly practiced in the 16th and 17th centuries when citrus was grown as an exotic ornamental in containers in orangeries.

In Florida, grafted trees came into use around 1830 when wild groves of sour orange were topworked with sweet orange to prevent tree decline from phytophthora root rot. Large-scale nursery propagations of grafted trees began in the second half of the 19th century. In addition to preventing tree decline from soil-borne diseases such as phytophthora root rot, grafting can protect trees from other stresses and diseases and influence the horticultural characteristics of the scion.

Most commercial citrus nurseries in Florida use a grafting (budding) method in which a bud from the desired scion cultivar is slipped under the bark of the rootstock after making an incision, usually in the form of an inverted T (see edis.ifas.ufl.edu/publication/HS1309). A functional graft union is a complex process that is initiated by the formation of callus tissue that fills up the spaces between the grafting partners (Figure 1). This is followed by the regeneration of new cambium and the formation of new vascular tissue (phloem and xylem) permitting the connection of scion and rootstock to form a functional unit.

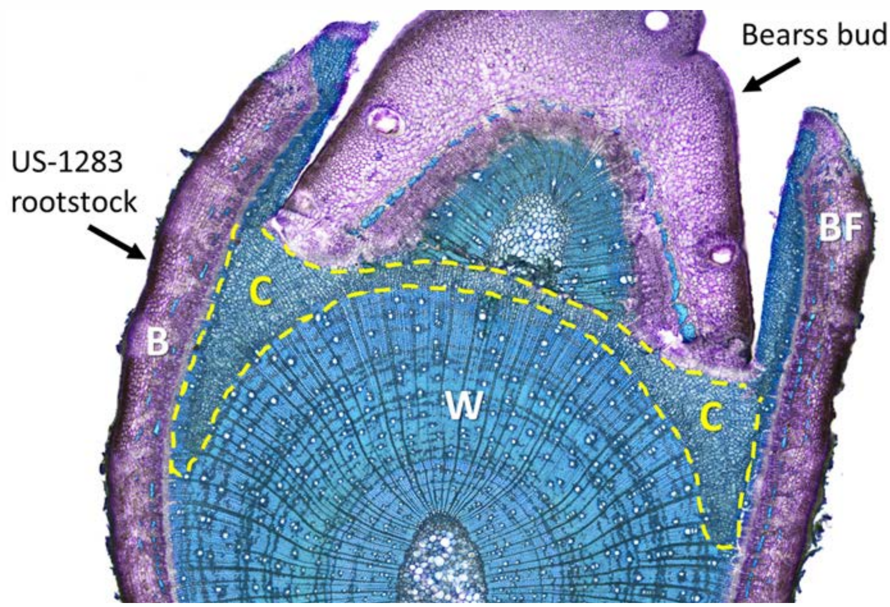

Figure 1. Microscopic cross section of the union between Bearss and US-1283 taken 15 days after budding using the inverted T method. Note the callus (C) tissue within the dashed yellow line filling the space between bud and rootstock. Tissue was stained with the dye toluidine blue. B = bark, BF = bark flap, W = wood, C = callus.

A close genetic relationship between stock and scion will usually result in a healthy graft union and healthy tree growth. When this happens, the scion-rootstock combination is considered compatible. The more distant the genetic relationship between the grafting partners, the more likely the chance that the graft combination will be incompatible, resulting in the graft union failing and tree decline or death. However, sometimes graft incompatibility occurs even when the scion and rootstock are not particularly distant in relationship.

The smoothness of the bud union is thought to be indicative of the compatibility between the grafting partners. The overgrowth of some cultivars does not always indicate an incompatibility but can be attributed to the different vigor of the grafting partners. A case in point is Swingle, which produces a very large root trunk relative to the sweet orange and other scion trunks. However, this does not usually result in a tree that will exhibit any more serious symptoms of graft incompatibility.

TYPES OF INCOMPATIBILITY

Incompatibility is defined as the failure of a graft combination (immediate or delayed) to form a strong union and remain healthy due to developmental, physiological or anatomical differences. There are three types of incompatibilities: 1) translocated incompatibility, which usually manifests during the first year after grafting; 2) localized incompatibility, which can take many years to manifest, often with breakage at the graft union; and 3) virus-induced incompatibility, which occurs when the scion and rootstock have different sensitivities to a virus. A known example is citrus tristeza virus, which causes incompatibility in most scions with sour orange rootstock. The exact mechanisms of incompatibility are not clear and are complicated by the fact that translocated and localized incompatibility often occur simultaneously, preventing a clear diagnosis during the early stages of growth.

New scions and rootstocks are being developed in Florida at an unprecedented pace to provide superior cultivars that survive in an HLB-endemic environment. Testing these scions and rootstocks and their different combinations takes a long time. In most cases, numerous combinations of specialty scions and rootstocks are being evaluated only after the commercial release of the individual cultivars.

INCOMPATIBILITY EXAMPLES

In 2014, the rootstock US-1283 was released by the U.S. Department of Agriculture based on over 14 years of field performance with Hamlin scion. US-1283 is a mandarin × trifoliate orange hybrid like many other rootstock cultivars. During propagations for new field trials over the last three years, abnormal growth was observed for this rootstock in combination with Bearss lemon, Star Ruby grapefruit and Tango mandarin. A virus analysis against the Division of Plant Industry (DPI)-mandated panel of viruses yielded negative results.

Figure 2. Scion swelling (left) and severe rootstock grooving (center) for graft combinations of Bearss and Star Ruby with US-1283. The picture on the right shows the necrosis of the rootstock trunk in the grooved regions after bark removal (scion is not shown).

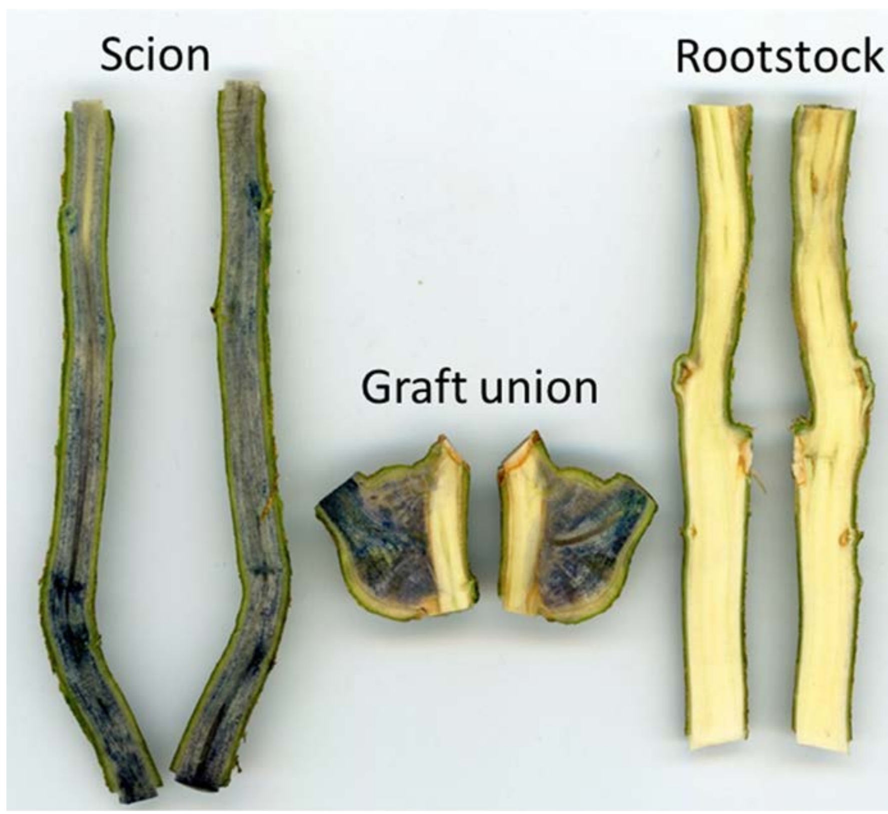

Figure 3. Starch accumulations in the Bearss scion with sharp gradient at the graft union. The plant was cut lengthwise, and an iodine tincture was applied on the cut surface. Iodine forms a deep blue-black complex with starch.

The incompatibility reaction appeared to be most consistent with Bearss lemon. It manifested as a swelling above the graft union, sometimes with extensive overgrowth of the graft union (Figure 2). In addition to the scion swelling, the rootstock assumed a ropy or grooved appearance. Necrotic areas were found in these grooved regions underneath the bark. Sap extrusion near the graft union was also found in some of these plants. Symptoms were variable in their intensity and ranged from mild to severe. In some cases, the plants died.

Similar incompatibility symptoms were observed for Star Ruby plants and sometimes accompanied by leaf chlorosis. The symptoms were often not evident until many months after grafting. Tango scion grafted on US-1283 exhibited no scion swelling, but some rootstock grooving and leaf chlorosis; the latter disappeared after a few weeks.

A similar incompatibility that manifested early was observed in the recently released University of Florida-Gainesville scion cultivars Sherman and Sunray when budded on US-942. Both cultivars show scion swelling above the graft union and a necrotic ring at the graft union. The scion growth is stunted and chlorotic, leading to premature scion death. Viral indexing of the scion varieties by DPI failed to detect the presence of viruses in the two scions.

Although the delayed manifestation of symptoms on US-1283 suggests an anatomical incompatibility, starch accumulation above the graft union suggests phloem degeneration, which is usually associated with a translocated incompatibility (Figure 3, page 12). Phloem degeneration and the resulting blockage of photosynthate transport across the graft union also explain the degeneration of the rootstock, which manifested as grooving. However, the starch gradient was not observed in plants that did not exhibit severe scion swelling while still exhibiting rootstock grooving or necrosis. During the second round of propagations, rootstock grooving was the main indicator of an incompatibility reaction while swelling was less noticeable.

ONGOING RESEARCH AND RECOMMENDATIONS

Researchers are currently investigating the anatomical and physiological mechanisms of these incompatibility reactions to identify a marker for the early diagnosis of scion–rootstock incompatibility. This would prevent economic losses as the incompatibility reaction may not appear until after field planting. So far, preliminary studies have not identified any abnormalities during callus formation and vascular differentiation at the graft union during the early stages of graft formation, hindering an early diagnosis.

When propagating new combinations of scions and rootstocks, it is, therefore, advisable to pay close attention to any abnormal swelling of the scion trunk or abnormalities of the rootstock trunk (grooving and necrosis underneath the bark) to detect potential incompatibilities and prevent economic losses.

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