GRAFTING OF *Acacia koa* Gray ONTO YOUNG *ACACIA* SEEDLINGS

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ABSTRACT

Scions of *Acacia koa* Gray (Fabaceae) were grafted onto rootstocks of *A. koa, A. mangium* Willd., and *A. confusa* Merr. using cleft or splice grafts applied to very young seedlings. This is the first report of grafting success between *A. koa* and any *Acacia* species. *Acacia koa* scion plants at the second true leaf stage of development were joined with the *Acacia* rootstocks of similar phenology just below the cotyledons. The initial grafting trials resulted in success rates from 20% to 70%. Graft unions were completely healed within 8 wk, and plants were ready for transplanting at about 3 mo. These methods allow for the production of grafted *A. koa* seedlings with potentially increased disease resistance, improved horticultural performance, and potentially wider adaptation to Hawaiian ecosystems and landscapes.

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KEY WORDS
Acacia koa, *Acacia mangium*, *Acacia confusa*, cleft grafting, splice grafting, disease resistance, koa wilt

NOMENCLATURE
USDA NRCS (2005)

Photos by SC Nelson

Figure 1. Cleft graft, 2 wk after joining scion (*A. koa*) with rootstock (*A. koa*).

Acacia is a genus of about 1300 species of shrubs and trees belonging to the subfamily Mimosodeae of the pea family Fabaceae. Koa (*Acacia koa* Gray) is endemic to the Hawaiian Islands and is the second most abundant overstory species in upper elevation forests in Hawai‘i. It forms nearly pure stands in montane forests, such as those on the slopes of Mauna Loa, between approximately 1230 and 2150 m (4059 and 7095 ft) (Whitesell 1990).

Koa is of critical ecological, social, and economic importance to Hawai‘i. Ecologically, koa provides habitat for numerous native birds, insects, and other flora and fauna. As a nitrogen-fixing leguminous species, koa is thought to account significantly for the nitrogen content of otherwise nitrogen-poor volcanic forest soils (Whitesell 1990). Socially, koa is a prominent component of Hawaiian legends and culture. Economically, koa is considered the most valuable of the common native Hawaiian timber species, valued at about US$ 40 per board foot. Koa wood, sometimes referred to as "Hawaiian mahogany," can be highly polished to emphasize its deep reddish coloration with wavy ("curly") grain and is used for furniture, paneling, voyaging canoes, and such woodworking crafts as bowls and ukuleles.

A number of significant soilborne pests, including root-knot nematodes (*Meloidogyne* spp.) and vascular wilt fungi (Gardner 1996), severely affect koa in Hawai‘i. Of these, koa wilt is probably the most prevalent and devastating disease (Anderson and Gardner 1998). Often fatal to koa, this poorly understood disease is believed to be caused by the soilborne fungus *Fusarium oxysporum* f. sp. *koae* (Gardner 1980; Anderson and others 2002), although other factors and possibly pathogens are implicated in disease etiology (koa wilt is perhaps a complex of *F. solani* and *F. oxysporum* [James 2006]). The disease is a major threat to the cultivation of koa at some locations in Hawai‘i.

Grafting onto disease-resistant rootstocks of related plant species and varieties is one of the best solutions for managing a number of soilborne plant pests. Although attempts to graft some *Acacia* species have been successful using various *in vivo* and *in vitro* methods (Danthu and others 1998; Monteuuis 1995 and 1996; Palma and others 1996 and 1997), previous attempts to graft *A. koa*—even when using a variety of approaches—met with failure (Skolmen 1978). A young seedling grafting method apparently has not been attempted for koa, even though an identical seedling graft method is useful in other systems such as commercial coffee production in Hawai‘i. We believe that *A. mangium* and other *Acacia* species may possess useful immunity or resistance to koa wilt and therefore may be valuable rootstocks if a method for grafting them can be developed.

The objective of this research was to test the hypothesis that *A. koa* could be grafted successfully onto young seedlings of *A. koa* and other *Acacia* species by applying a simple cleft- or splice-grafting method. If successful, it might allow koa to be grafted and grown successfully in the presence of the deadly and destructive soilborne plant pathogens that plague it in Hawai‘i.

MATERIALS AND METHODS

Seeds of *A. koa, A. mangium,* and *A. confusa* were collected in 2004 and 2005 from plants growing on the island of Hawai‘i. Seeds were scarified by hot water (Friday 2000). Distilled water was brought to a boil, removed from the heat to cool slightly, and poured over the seeds. After 2 min, the hot water was replaced with cool distilled water and the seeds were soaked overnight before planting.

Scarified seeds were planted into seedling trays containing a 3:1:1 mixture of peat, vermiculite, and commercial potting soil. Seedling flats were placed in a 60% shadehouse and watered twice daily. After seed germination, plants were inoculated to fix nitrogen with aqueous suspensions of crushed *Bradyrhizobium* nodules obtained from greenhouse cultures growing on each of the 3 *Acacia* species. *Acacia* seedlings were left to grow under greenhouse conditions until the first 2 sets of true leaves had emerged, at which point they were used as rootstocks for grafting.

Grafting *A. koa* onto *A. koa*

To obtain scions, seedlings of *A. koa* at the 1 to 2 true leaf stage were decapitated with a scalpel 1 to 2 cm (0.4 to 0.8 in) below the cotyledons. At this phenological stage, stems were approximately 2 to 4 mm (0.08 to 0.16 in) wide. To obtain rootstocks, seedlings of identical phenology were decapitated with a scalpel just below the cotyledons. A longitudinal split (3 to 6 mm [0.12 to 0.24 in]) in the stem of the rootstock was made with the scalpel. The scion's stem was trimmed to a wedge shape to match the cleft created in the rootstock (Figure 1). The trimmed scion was then inserted into the split stem of the rootstock so that at least part of the cambium layers of the 2 plants became aligned. A standard small grafting clip, with pieces of soft foam rubber attached, secured the graft union (Figure 2). Grafted plants were placed in a Plexiglas moist chamber at room temperature under diffuse, natural light next to a window for 5 to 7 d, after which the grafting clips were removed. Two wk after clips were removed, plants were moved to a 60% shadehouse and managed for further grow. For plants joined by splice grafts, the process was similar except that stems were cut at rather acute, complementary angles instead of wedges (Figure 3).

Grafting *A. koa* onto *A. mangium* and *A. confusa*

To join *A. koa* onto dissimilar *Acacia* species, the same method described above was used for growing the seedlings, for preparing them as scions, and for grafting. *Acacia mangium* seedlings, however, had

Figure 2. Grafting clips were needed for about 2 wk.

Figure 3. Splice graft, 3 wk after joining scion (*A. koa*) with rootstock (*A. confusa*).

Figure 4. Cleft graft union 8 wk after joining scion (*A. koa*) and rootstock (*A. mangium*).

to be planted earlier and allowed to grow 2 mo longer than the *A. koa* seedlings to become large enough to match the stem size of *A. koa* scions of similar phenology. *Acacia confusa* seeds were planted at the same time *A. koa* seeds were planted because they grew and developed at similar rates. Cleft grafts were used primarily to join *A. koa* and *A. mangium*. Splice grafts were used primarily to join *A. koa* and *A. confusa* because the plants grow at similar rates as seedlings, the graft unions heal rapidly, and the splice grafts were quicker to perform. Grafted seedlings were placed in humid chambers at room temperature for 1 wk before grafting clips were removed. Plants were transferred to the 60% shadehouse 2 wk later for further growth and development.

RESULTS

Grafting success rates achieved in our first trials varied among species. The success rate was approximately 70% for *A. koa* to *A. koa* grafts and for *A. koa* to *A. confusa* grafts. The success rate was 20% to 25% for *A. koa* to *A. mangium* grafts. The grafting process was very simple and fairly rapid; a pair of seedlings could be joined and clipped together at a rate of 2 to 3 min initially and then at 1 min or less after practice. Graft unions healed completely by about 8 wk after grafting (Figure 4). Plants at 6 mo after grafting (still in pots) reached a height of more than 1.5 m (5 ft) (Figure 5).

Plants joined by cleft grafts were somewhat sturdier than plants joined by splice grafts. Splice-grafted plants tended to become top heavy, leaning over at the point of graft union, and had to be supported with small wooden stakes or toothpicks.

DISCUSSION

This is the first report of successful grafting of *A. koa* onto *A. koa* or any other *Acacia* species. The method proved to be quick, relatively inexpensive, and easy to use.

The margin of error is very small when grafting *Acacia* seedlings at this stage of growth, because the narrow stem diameters require very precise alignment of the scion and rootstock, and the young stem tissues are easily damaged. Although grafting was possible, a relatively high percentage of failed grafts occurred when grafting *A. koa* onto *A. mangium* seedlings. Further grafting practice, as well as determining optimum conditions for holding the plants while the grafts heal, may improve the percentage of successful grafts. But the difficulty we experienced grafting *A. koa* onto *A. mangium* could indicate a level of graft incompatibilty that may eventually cause problems at the graft union. Time will tell if the graft unions are durable—long-term observations of grafted plants are needed to ensure their long-term suitability. Preliminary data are promising; we have 9-mo-old grafted plants (one planted outside) that are taller than 3 m (10 ft) and show no sign of graft union incompatibility. (Figure 6) Overall, after 9 mo the graft unions between *A. koa* and *A. mangium* had much better, seamless graft unions than did grafts between *A. koa* and *A. confusa*.

The need to grow the *A. mangium* seedlings for 2 mo (or longer) before using them as rootstocks resulted in stems that were not as tender and were woodier than *A. koa* scions. The joining of very tender tissue with more woody tissue is perhaps another factor that reduced the percentage of successful grafts between the 2 species.

Our results suggest that *A. koa* may have a wide grafting compatibility with *Acacia* species; we intend to examine the use of other *Acacia* species as rootstocks. These grafting methods may be useful to join dissimilar koa families with various horticultural or genetic attributes as well, perhaps allowing adaptation of desirable koa families to a wider range of environments in Hawai‘i. We were able to graft dissimilar *A. koa* families from different islands in this study (data not presented).

Figure 5. Grafted *A. koa* plant 6 mo after grafting onto *A. mangium* rootstock.

Figure 6. A 13-mo-old *A. koa* grafted onto a *A. mangium.*

Nonnative sprouts possibly arising from the rootstock tissue is not an anticipated issue because the graft union was made below all meristematic tissues of the rootstock (that is, below the cotyledons).

CONCLUSION

Simple and relatively reliable, these grafting methods for *Acacia koa* could be applied to other species within the genus *Acacia* to provide a disease- or pest-control tactic with potential for forestry applications if the cost to produce grafted trees is held low enough to make large-scale production economically feasible. However, this grafting method should complement, not be a replacement for, other powerful tools for disease mitigation, such as tree breeding.

We have immediate plans to test the *A. mangium* and *A. confusa* rootstocks against the fungal pathogens in the koa wilt complex and against root-knot nematodes. We intend also to examine the performance of grafted plants transplanted into forests or landscapes to evaulate the long-term compatibility of the graft union and the vigor of the plants.

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