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# KOA

*Acacia koa* Gray

| Kim M Wilkinson and Craig R Elevitch |

## KEY WORDS

Fabaceae, Hawai'i, scarification, *Rhizobium* inoculation

## NOMENCLATURE

USDA NRCS (2004)

**K**oa (*Acacia koa* Gray [Fabaceae]) is native to all 6 major Hawaiian Islands: Hawai'i, Moloka'i, Maui, Lāna'i, O'ahu, and Kaua'i. Its original range was from 90 to 2300 m (300 to 7500 ft). Today, the largest and most thriving koa trees are found between 900 and 1850 m (3000 to 6000 ft). Introduced pests and diseases limit koa's presence below 600 m (2000 ft).

## SEED COLLECTION, PROCESSING, AND PRETREATMENT

Flowering is seasonal in some areas, but in other areas it may occur year-round, with fruits ripening any time of year. Koa produces pods about 15 cm (6 in) long and 2 to 4 cm (1.0 to 1.5 in) wide. Each pod has 6 to 12 seeds. Pods are ready for harvest when brown, and when opened, seeds inside are deep brown and full (not green, flat, or small). Seeds may be collected from the tree by hand, with a pole pruner, or collected from the ground. Genetic quality is a crucial aspect of koa performance and yield, and source must be carefully considered and matched for the outplanting site before seeds are collected.

Pods are dried in the sun until they can be opened easily. Seeds are extracted by hand or by machine threshing. Once out of the pods, seeds may be dried more if necessary (ideal moisture content 6% to 8%). Dried seeds can then be stored in an airtight container away from direct sunlight. Properly dried seeds can be stored for 12 to 24 months at room temperature and for many years longer under cooler conditions.

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A 2-wk-old seedling (left) and 6-wk-old seedlings being spread to half density to improve growth (right). Photos by Craig R Elevitch

Koa seed size is highly variable, there can be 1134 to 3402 seeds/kg (2500 and 7500 seeds/lb). Germination is usually 70% or higher but can be low depending on weather conditions during ripening.

Koa seeds require scarification. Mechanical scarification (nicking with a nail clipper on the side opposite the point of attachment to the pod) is used for small lots. Hot water treatment also can be used: 90 °C (195 °F) in a volume ratio of at least 5 parts water to 1 part seed for 1 to 3 minutes. In all cases, scarified seeds are soaked overnight in cool water so that seeds fully imbibe before sowing. Following pretreatment, seeds germinate in 2 to 7 days.

## GROWING SEEDLINGS

Koa seedlings can be grown in an uncovered growing area. If available, some cover (greenhouse or temporary cover) is ideal for the first 2 wk after germination to protect sprouts from hard rains or seed-eating birds. Rodents also eat koa seeds and should be controlled. Seeds are sown into Ray Leach cells that are 164 ml (7 in<sup>3</sup>) or greater in volume. We use a well-drained growing medium of 2:1:1:1 (v:v:v:v) peat moss, perlite, vermiculite, and compost amended with 4:4:2:1 (v:v:v:v) dolomite lime, gypsum, endomycorrhizal inoculant (Bio Organics™ Mycorrhizae Inoculants, La Pine, Ore-

gon), and triple super phosphate at the rate of 2.5 l (88 oz) of amendments per 113 l (25 gal) of medium components.

Germinated seeds (sown on paper towels or in beds) are transplanted at a rate of 1 seed per cell into containers that have been prefilled with medium. We sow seeds as soon as the radicle emerges from the seed. Cover shallowly with medium mix, followed by a thin mulch layer such as #2 poultry grit. Water with a fine-headed sprayer to keep moist. Daily water is usually necessary, by hand or with an automated system.

After about 6 wk, seedlings may be double-spaced in the Ray Leach trays to ensure that each seedling receives full sunlight and to facilitate good stem development. After 1 to 2 wk of growth, seedlings should be inoculated with a *Rhizobium* nitrogen-fixing bacteria selected for this species. Alternately, a crude inoculant can be made from nodules, which are the small root structures that house the bacteria. When nitrogen fixation is taking place, nodules can be seen on the roots of the plants, and each one of the nodules can house millions of bacteria. For *Rhizobium*, a brown, pink, or red color inside the nodule is usually a good indicator that the nodule is active. Collect nodules from healthy, vigorous plants from forest, field, or nursery. Young roots often contain the most active nodules. If possible, collect nod-

ules from several trees. Place nodules into a baggie or plastic container and place in a cooler, protecting them from direct sunlight and heat. As soon as possible after collection (within a few hours), put nodules into a blender with clean, chlorine-free water. This solution is a homemade liquid inoculant, ready to apply.

Inoculation (infecting the seedling roots with the bacteria) should take place as early in the seedling's life as possible, when the plant will most readily form the association. In nursery conditions, inoculant for nitrogen-fixing bacteria is commonly applied when seedlings are just emerging, less than 3 wk old. One liter of liquefied inoculant made from blending 50 to 100 nodules is diluted in more chlorine-free water. For 500 seedlings, about 1 l (0.22 gal) of water is used. This solution is then dispensed into the root system of each seedling using a watering can. No fertilizer application is necessary if seedlings are inoculated with *Rhizobium* bacteria and mycorrhizal fungi.

Because seedlings are kept outside, exposed to full sunlight, not fertilized, and watered as necessary during most of their life, a separate hardening-off phase is usually not necessary. Growers should continue to ensure that seedlings receive full sun, spacing seedlings farther apart if necessary. Seedlings should never be



*Rhizobium root nodules on a 12-wk-old seedling that was inoculated with selected laboratory cultures when it was 2 wk old (left) and a 12-wk-old seedling being outplanted in a prepared field (right). Photos by Craig R Elevitch*

allowed to dry out, but watering frequency may be reduced to introduce seedlings to temporary, moderate water stress. Seedlings can be grown to out-planting size in 4 mo.

### OUTPLANTING

Koa is highly variable in size, form, and site performance. Hawai'i's many varied climates mean that local populations are often best adapted for the particular conditions of any site. For this reason, a

quality seed source should be found as close to the outplanting site as possible. When that is not possible, seeds should be collected from areas with similar conditions (rainfall, drought period length, pest populations, soil conditions, and so on). Areas above 457 to

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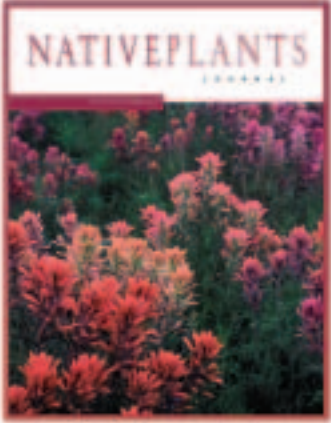
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610 m (1500 to 2000 ft) elevation are considered best for planting koa. Lower elevation koa trees often succumb to introduced pests or diseases, such as the black twig borer, or to fungi, such as *Fusarium* spp. For areas with a pronounced dry season, seedlings are typically planted at the onset of the rainy season. For areas that receive sufficient rainfall throughout the year, the onset of summer (in March or April) is an optimal time for outplanting.

Site preparation is a crucial part of koa establishment. The area must be fenced to exclude any grazing animals (domesticated or feral), and competitive vegetation must be removed. At outplanting time, seedlings should be carefully removed from their containers and planted at the correct depth, which has the ground even with the root collar. Soil should be firmed around the tree. Water should be supplied if the soil is not moist enough. If possible, a weed barrier of mulch around the tree (but not touching the trunk) can aid koa establishment. Spacing for koa is a much-debated topic, and no firm guidelines have been established. Spacings that are commonly used at this time include 1.8 x 2.7 m (6 x 9 ft), 2.4 x 2.4 m (8 x 8 ft), or 3.0 x 3.0 m (10 x 10 ft) (Wilkinson and Elevitch 2003). Koa is a hardy pioneer species, and survival is usually very high (over 90%) after outplanting on well-prepared sites.

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