

# Seed Source and Performance in Koa Tree Establishment

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## The story in brief

When planting trees it is important to consider using seeds of trees with desirable characteristics. This study shows that seed provenances of trees from similar environment should also be considered when preparing a plan for planting trees. Different seed sources of koa are used for tree establishment or reforestation and this study confirms the importance of choosing the proper provenance.

## Introduction

A study was done in central Oahu to compare the performance of koa from the islands of Hawaii, Maui, Oahu, and Kauai growing together in a single setting. The main objective was to determine the effect of a seed source on survival and growth of koa seedlings in the western Koolau foothills of central Oahu.

## Materials and methods

The study was located at the Waiawa Correctional Facility located in central Oahu at about 800-foot elevation in the Koolau foothills. The mean annual rainfall during the study from 1991 through March 1994 was 55 inches. The mean air temperature was 71.5°F with a maximum and minimum of 79.6 and 65.6°F. The soil is classified as an Oxisol, it therefore has a low cation exchange capacity. Moderate to high phosphorus fixation limits availability to plants.

Eight *Acacia koa* provenances native to sites on four islands were used in this study. The most recent published flora of Hawaii treats all the endemic *Acacia* varieties as a single species (Wagner et al. 1990). There are however some relatively distinct characteristics about the Kohala and Kamalomaloo provenances from the islands of Hawaii and Kauai that have lead many to view them as subspecies of *A. koa*.

Elevation, mean annual temperature and rainfall, and soil orders of the seed source locations are given in Table 1. The data indicate that the habitats of the Maui, Oahu, and Kauai provenances are more similar to Waiawa than those of the island of Hawaii (Big Island). Three of the four Big Island seed source locations are at higher elevation with cooler and wetter climates than at the Oahu study location.

Except for the Mollisol from Kaupo, all of the soils are highly acidic and fix phosphorus. The Andisols from the Big Island have more capacity to fix phosphorus than the Oxisols and Ultisols from the other islands. The Andisols also have high cation exchange capacity and high buffer capacity with

**Table 1. Environmental characteristics of the eight seed source locations of koa.**

Source	Elev. ft	Temp. °F	Rain in.	Soil order
Hawaii				
Kaumana	2200	66	140	Andisol
Kukaiau	3800	61	120	Andisol
Hakalau	6200	56	100	Andisol
Kohala	3000	66	40	Andisol
Maui				
Kuiaha	1000	70	80	Ultisol
Kaupo	1400	60	60	Mollisol
Oahu				
Koa ridge	800	72	55	Oxisol
Kauai				
Kamalomaloo	500	73	65	Ultisol

the exchange sites mostly hydrogen-saturated. Mollisols are generally fertile with near-neutral pH and are better suited for plant growth than the other soils.

The eight provenances were planted in a randomized block design with four replications. Forty-eight seedlings were planted and spot fertilized with 14-14-14 nitrogen, phosphorus, and potassium fertilizer in a 6- by 8-tree layout. The interior 24 trees were used as measure trees.

The seedlings were grown in 5-inch dibble tubes and all but the Kaumana and part of the Kamalomaloo provenances were planted in January and February 1991. The Kaumana and remaining Kamalomaloo seedlings were planted in February 1992. Tree height and stem diameter at breast height were measured once each year until March 1994. Health, survival, foliage characteristics, and tree form were also recorded at each measurement.

## Results

Initial tree height, growth rate, total growth, and survival of the trees are given in Table 2. The koa ridge provenance came from a location adjacent to the Waiawa Correctional Facility and grew better than any of the other selections. The Kamalomaloo koa from Kauai grew nearly as well. The other provenances were considerably behind these two leaders.

There was considerable difference in the size of the seedlings when they were planted but this did not seem to be correlated with either survival or growth. We generally recommend that seedlings grown in small dibble tubes be planted in the field when they are between seven and 10 inches tall.

**Table 2. Average growth rate, total growth, and survival of eight provenances of koa at Waiawa on Oahu, Hawaii.**

Source	Initial ht. in.	Growth in./mon.	Total in.	Survival Percent
Hawaii				
Kaumana	19.4	0.70	9.8	64
Kukaiau	13.8	0.38	13.9	64
Hakalau	9.6	0.28	10.3	52
Kohala	27.1	0.99	36.4	70
Maui				
Kuiaha	10.8	1.25	45.9	79
Kaupo	11.5	1.61	58.9	70
Oahu				
Koa ridge	10.8	2.39	87.7	79
Kauai				
Kamalomaloo	6.3	2.17	79.7	98

The Kukaiau, Hakalau, and Kohala provenances grew more slowly than the others during the first nine months after planting and were later severely attacked by insects. The provenances that grew most during the first period were the koa ridge and Kamalomaloo seed sources and they were not subjected to insect attack.

Slow growth and poor plant health may have resulted from low soil fertility associated with soil fixation of phosphorus. To alleviate this problem, a second application of 14-14-14 fertilizer was applied in January 1993. Insect attacks were reduced and growth improved following fertilizer application. Wind and low humidity can add to or compound stress associated with poor fertility. Rainfall is low at Waiawa, adding still more stress. The combined effects of these may result in insect attacks on the provenances that evolved where weather was more favorable.

Subtle morphological differences are more easily observed when provenances are grown in the one location. The Kamalomaloo and the Kohalo provenances grew well but they both exhibited a more bushy form than the other provenances. Flowers of the Kamalomaloo provenance were light yellow in compact clusters at the ends of branches. The few flowers observed on the other koa were nearly white and less strongly bunched at the branch ends.

### Conclusions

The evidence strongly suggests that the environmental characteristics of a site where koa is to be planted should dictate the seed source selected. The ability of a koa seedling to withstand the environmental stress where it is planted depends on where the provenance evolved. The physical appearance of various provenances also depend on evolutionary differences caused by environment and chance. Maintaining genetically pure provenances may be important for assuring high quality stock for future plantings in restoring native Hawaiian forests.

### Literature cited

Wagner, Warren L., Derral R. Herbst, and S. H. Sohmer. 1990. Manual of the flowering plants of Hawaii. Bishop Museum Special Publication 83. University of Hawaii Press. Honolulu, HI. 1853 pp.

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