‘KX4-Hawaii’, Seedless Interspecific Hybrid Leucaena

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‘KX4-Hawaii’ is a tropical, seedless, multipurpose legume tree developed at the College of Tropical Agriculture and Human Resources of the University of Hawaii. It represents a sterile triploid hybrid between Leucaena leucocephala (Lam.) de Wit ssp. glabrata (Rose) S. Zárate (2n = 104) and L. esculenta (Mocíño et Sesse ex DC) Benth. (2n = 52). ‘KX4-Hawaii’ is a rapidly growing tree to 15 m in five years. Its evergreen canopy is open and it has proved to be attractive as an ornamental, windbreak, and shade tree. It has potential also for use as a coppiceable, high-value hardwood grown on eight- to 12-year rotations. It is normally single-stemmed with major branches arising at 3 m or higher. It can be coppiced to create a multistemmed tree for biofuel and is readily cloned. It has been grown in many locations throughout Hawaii, showing high drought tolerance and wide environmental adaptability. It has no known pests or diseases.

Several of the 22 recognized species in the New World genus Leucaena (Hughes, 1997) are grown as shade or ornamental trees. Two species are widely cultivated internationally, L. leucocephala (Lam.) de Wit and L. diversifolia (Schlecht) Benth. Both are recognized as shade or support trees for crops like coffee, cacao, pepper, and quinine, and both are self-seeding polyploids (2n = 104). Leucaena leucocephala ssp. glabrata (formerly known as L. glabrata Rose) is the widely grown multipurpose subspecies that is highly valued for timber, fuelwood, fodder, food, and green manure (Anon., 1977; Shelton and Brewbaker, 1994). Significant cultivars bred in Hawaii include K8 (Brewbaker, 1975) and K636, marketed as “Tarramba” (Dalzell et al., 2006). New hybrids such as ‘KX2-Hawaii’ have been bred to be largely self-sterile, similar to most species of the genus (Brewbaker, 2008). Self-seediness is associated with invasiveness and can greatly reduce wood and fodder yields of tropical legumes. These facts encouraged our extensive evaluations of the

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Origin

‘KX4-Hawaii’ is a triploid hybrid of the meso-American species Leucaena leucocephala ssp. glabrata (2n = 104) and Leucaena esculenta (2n = 52). The 1100 leucaena accessions and hybrids grown in Hawaii have been designated by the symbol K (“koa haleo,” a local name) with species hybrids designated KX. The female parent of ‘KX4 Hawaii’ was accession K636 (PI443740) of L. leucocephala ssp. glabrata that was collected in 1978 by the author and A.J. Oakes from in Saltillo, Coahuila, Mexico. It represents the arboreal subspecies glabrata that has gained international use (Shelton and Brewbaker, 1994) as a multipurpose legume tree (forage, hardwood, fuelwood, shade, green manure). The pure-line bred from K636 also served as the parent of the widely grown forage cultivar Tarramba from Australia (Dalzell et al., 2006).

The male parent of ‘KX4-Hawaii’ was provenance K838 of L. esculenta (Mocíño et Sesse ex DC) Benth. This species is widely grown in the highlands of Mexico, where its seeds and pods are highly valued as a food (Hughes, 1997). K838 was collected in 1985 by the author from trees 30 km north of Chihuahua in the state of Guerrero, Mexico. It was verified to be a typical self-sterile L. esculenta with 2n = 52 (Pan, 1985). Trees are distinctly arboreal with large concave leaf glands, corky bark, and ridged shoots. L. esculenta was shown by Austin et al. (1995) to be resistant to the internationally common psyllid insect, Heteropsylla cubana Crawford. These authors also concluded that L. esculenta was of limited interest as a forage legume as a result of high tannin levels and low digestibility. The esculentas do not survive well at low elevations in Hawaii and flower in late fall after leucaephas has gone to seed, making hybridization difficult.

Interspecific hybridization in the genus Leucaena was initiated by the author in 1962 in the Hawaii-based provenance collection (Bray et al., 1997). Hybridization was focused on improvements of the arboreal subspecies L. leucocephala ssp. glabrata. Interspecific crosses with the diploid (2n = 52) L. pulverulenta (Schlecht.) Benth. were initiated by

Gonzalez et al. (1967). Pan (1985) extended the hybridization to L. diversifolia (Schlecht.) Benth. (2n = 104), L. trichandra (Zucc.) Urban (2n = 52, as “Div2n”), L. shannonii Donn. Smith (2n = 56), and L. pallida Britton and Rose (2n = 104). Pan and Brewbaker (1988) verified that all diploid species of the genus, including L. esculenta, were self-sterile, whereas the tetraploid species L. leucocephala was self-fertile and L. pallida was uniquely self-sterile. A self-sterile population derived through a recurrent selection from L. pallida × L. leucocephala was released as ‘KX2 Hawaii’ by Brewbaker (2008), and a self-fertile version is being released for fodder in Australia in Mar. 2013.

Pollinations that led to ‘KX4 Hawaii’ were made by Sorensen (1993) in his extensive hybridizations among 15 species of the genus. When the self-sterile L. esculenta (2n = 52) was used as the female parent, 140 florets produced an average of 2.4 seeds per 10 florets, indicating weak compatibility (Sorensen and Brewbaker, 1994). However, when the self-fertile L. leucocephala (2n = 104) was emasculated and crossed as the female parent, 281 florets produced an average of 64 seeds per 10 florets, indicating high compatibly (~50% of seed set by compatible selfs). The hybrid seeds from which ‘KX4-Hawaii’ is derived were from crosses of the pure line K636 of L. leucocephala ssp. glabrata as the female parent (emasculated) and several trees of the self-sterile K838 of L. esculenta as the male parent. Greenhouse-grown seedlings were planted in 1988 of which 23 trees survived and were easily distinguished from their parents. These were rogued to 10 trees from which four have been widely studied as clones using vegetative propagation methods of Shi and Brewbaker (2006).

Description

Yield and psyllid resistance. Interspecific hybrids of L. leucocephala ssp. glabrata × L. esculenta are arboreal, vigorous vegetatively, and generally outperform our best cultivars of L. leucocephala ssp. glabrata. This is most evident after summer flowering when vegetative growth of the self-sterile parent slows during fruiting and pod formation, a three-month process. The leucaena psyllid, Heteropsylla cubana (Crawford), is the sole acknowledged serious insect pest of leucaenas, and most of our accessions of L. leucocephala were susceptible (Austin et al., 1995). ‘KX4 Hawaii’ and all accessions of L. esculenta proved to be psyllid-resistant. No other diseases or pests have been observed on the several hundred trees of ‘KX4-Hawaii’ that have been planted from coastal sands to our highland Mealani Research Station (900 m). No evidence has been obtained to suggest that ‘KX4 Hawaii’ is different in tolerance of drought, salinity, or phosphate deficiency than L. leucocephala, but it may have more cold tolerance.

Horticultural characteristics. ‘KX4-Hawaii’ grows to a mature height of ~15 m in six to eight years and is strongly arboreal (Fig. 1). The 10-year-old tree in Figure 1A had grown in
20 years to a height of 19 m and diameter at breast height of 53 cm. The trees rarely fork under a height of 3 m. Flowering begins within two years and tends to be year-round in Hawaii with the tiny white florets often carpeting lawns inconspicuously. Ten-year-old trees grown at normal 2.5 m × 2.5-m spacing appear to be economically harvestable as hardwood with greater than 25 cm diameter and ∼0.6 specific gravity. The heartwood is an attractive reddish brown, and sapwood occupied 22% of the diameter of sampled 10-year-old trees. Stem regrowth of KX4 clones after coppicing can be dramatic in Hawaii (Fig. 1B), suggesting adaptability of this tree to biofuel harvest and encouraging appropriate yield trials.

‘KX4-Hawaii’ is easily distinguished from its parents by its seedlessness. Several morphological traits of leaves and flower heads also distinguish the hybrid (Table 1) and are generally intermediate to those of its parents. Similar naturally occurring hybrids of L. esculenta with L. leucocephala and L. pallida were commonly encountered in our University of Hawaii expeditions of 1978 and 1985 in Mexico. Hughes (1997) later chose to describe taxonomically the leucocephala × esculenta hybrids as L. × mixtec. C. E. Hughes, suggesting they were hybrids with the ssp. glabrata. However, he recorded that seedless hybrids were often small trees with spreading habit and short boles, confirming our conclusion in the field that many were hybrids with the widely distributed and shrubby ssp. leucocephala. Early botanists treated the arborescent leucaenas as a distinct species, L. glabrata Rose, and we called them “Hawaiian giants” while naming K8 (Brewbaker, 1975). However, Zárate (1987) chose to treat the glabratas as a subspecies of L. leucocephala. Of the 473 accessions of L. leucocephala we have evaluated in replicated trials since 1962 in Hawaii, the 120 glabratas (arboreal) types were always readily distinguished from the 353 shrubby subspecies and argue for specific status of the glabratas. The ssp. leucocephala was introduced to the Philippines with the Spanish galleons in the 16th century for fodder and fuelwood (Anon., 1977). This highly forked and seedy tree with small leaves, pods, and seeds was spread worldwide and often became weedy and invasive. Known as ‘koa haole’ in Hawaii (Brewbaker, 2010), it showed no molecular diversity and was never used to breed improved cultivars. Under natural conditions in Meso-America, the leucaenas are usually harvested, often browsed by animals, and grown under stresses that might have led Zárate (1987) to favor a subspecies distinction between the shrubby ssp. leucocephala and the arborescent ssp. glabrata. Horticulturally, only the arborescent glabrata serve consideration for cultivar improvement (Brewbaker, 1975) or for hybrids like KX2 and KX4 (Brewbaker, 2008, 2010; Shelton and Brewbaker, 1994).

Narrowly spaced linear plantings of ‘KX4-Hawaii’ (1 m between trees) have been attractive in Hawaii for building shade (Fig. 1C) and as windbreaks. The wide crown growth in linear plantings was aided by coppicing plants at 1-m height six months after transplanting three-month-old cuttings. Vegetative propagation has been effective whether using short 5-cm sections in mist beds or by air-layering older stems (Shi and Brewbaker, 2006). To achieve strong taproot development (characteristic of leucaenas), these propagules are wisely made with root-pruning dibbletubes, because normal cuttings can lead to trees with superficial roots that resemble many tropical legume trees. Ongoing research with tissue culture and air-layered clones is focused on use as hardwood, shade tree, windbreak, and possibly biofuel.

**Availability**

Clonal cuttings of ‘KX4-Hawaii’ are available from Hawaii Foundation Seeds, Dept. of Tropical Plant and Soil Science, CTAHR, U. Hawaii, 3190 Maile Way, Honolulu, HI 96822 (<http://www.ctahr.hawaii.edu/hfs/>).

**Literature Cited**

Anon. 1977. Leucaena: Promising forage and tree crop for the tropics. U.S. National Academy of Science. Washington, DC.

Austin, M.T., C.T. Sorensson, J.L. Brewbaker, W.G. Sun, and H.M. Shelton. 1995. Forage dry matter yields and psyllid resistance of thirty-one leucaena selections in Hawaii. Agrofor. Syst. 31:211–222.

Bray, R.A., C.E. Hughes, J.L. Brewbaker, J. Hanson, B.D. Thomas, and A. Ortiz. 1997. The world Leucaena catalogue. Dept. Agriculture, U. Queensland, Brisbane, Australia.

Brewbaker, J.L. 1975. Registration of Hawaiian Giant K8 Leucaena. Crop Sci. 15:885–886.

Brewbaker, J.L. 2006. Registration of ‘KX2-Hawaii’, interspecific-hybrid leucaena. J. Plant Registration 2:190–193.

Brewbaker, J.L. 2010. Leucaena is not koa haole. Hawaii Forest Journal 5:7–8.

Dalzell, S., M. Shenton, B. Mullen, P. Larsen, and K. McLaughlin. 2006. Leucaena: A guide to establishment and management. Meat & Livestock Australia Ltd.

 Gonzalez, V., J.L. Brewbaker, and D.E. Hamill. 1967. Leucaena cytogenetics in relation to the breeding of low mimosine crops. Crop Sci. 7:140–143.

Hughes, C.E. 1997. Systematic botany monographs Vol. XX: Monograph of Leucaena (Leguminosae-Mimosoideae). Amer. Soc. of Plant Taxonomists.

Pan, F.J. 1985. Systematics and genetics of the Leucaena diversifolia complex. PhD thesis, Dept. Agronomy and Soil Science, Univ. Hawaii, Kailua, HI.

Pan, F.J. and J.L. Brewbaker. 1988. Cytological studies in the genus Leucaena Benth. Cytologia (Tokyo) 53:393–399.

Shelton, H.M. and J.L. Brewbaker. 1994. Leucaena leucocephala - the most widely used forage tree legume, p. 15–29. In: Gutteridge, R.C. and H.M. Shelton (eds.). Forage tree legumes in tropical agriculture. CAB International, London, UK.

Shi, X.B. and J.L. Brewbaker. 2006. Vegetative propagation of Leucaena hybrids by cuttings. Agrofor. Syst. 67:77–83.

Sorensson, C.T. 1993. Production and characterization of interspecific hybrids of the tropical tree Leucaena (Leguminosae-Mimosoideae). PhD thesis, University of Hawaii, Kailua, HI.

Sorensson, C.T. and J.L. Brewbaker. 1994. Interspecific compatibility among 15 Leucaena species (Leguminosae-Mimosoideae) via artificial hybridizations. Amer. J. Bot. 81:240–247.

Zárate, P.S. 1987. Taxonomic identity of L. leucocephala (Lam.) de Wit with a new combination. Phytologia 63:304–306.

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**Table 1. Average values of distinguishing morphological traits of ‘KX4-Hawaii’ and its parents.**

| Trait                  | L. esculenta | L. leucocephala | ‘KX4-Hawaii’ |
|------------------------|--------------|-----------------|--------------|
| Tree height (m)        | 12           | 14              | 12           |
| Leaf length (cm)       | 36           | 24              | 30           |
| Pairs of pinnae per leaf | 36       | 8               | 11           |
| Pairs of leaflets per pinna | 70      | 18              | 26           |
| Head diameter (mm)     | 20           | 25              | 25           |
| Anther color           | Pink         | White           | White        |

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Fig. 1. Trees of ‘KX4-Hawaii’ at Waimanalo, HI; (A) mature 10-year-old tree; (B) coppice regrowth at age 2.5 years; (C) narrowly spaced shade planting around Quonset hut at age 2.5 years.