Calliandra calothyrsus Meisn.

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FABACEAE (BEAN FAMILY)

Calliandra confusa Sprague & L. Riley; *Anneslia confusa* (Sprague & L. Riley) Britton & Rose; *Calliandra similis* Sprague & L. Riley; *Anneslia similis* (Sprague & L. Riley) Britton & Rose; *Anneslia acapulcensis* Britton & Rose; *Calliandra acapulcensis* (Britton & Rose) Standl. (Britton and Rose 1928, Sprague and Riley 1923, Standley 1936)

Barbe jolote, barbe sol, barbillo, cabellito, cabello de angel, calliandra, clavellino, kaliandra, pelo de angel (Macqueen and Hernández 1997)

Calliandra calothyrsus is native to the western Pacific coast of Mexico at Colima 19°04'N 103°45'W, with an outlying population in Veracruz, Mexico 19°20'N 96°20'W, through to the north coast of central Panama, 9°20'N 79°50'W. It is found in each of the following intervening countries and their states: Belize (Belize, El Cayo, Stann Creek, and Toledo); Costa Rica (Alajuela, Cartago, Guanacaste, Heredia, Limón, Puntarenas, and San José); El Salvador (Ahuachapán and Santa Ana); Guatemala (Alta Verapaz, El Progreso, Huehuetenango, Izabal, Petén, Quiché, Retalhuleu, Sacatepéquez, Santa Rosa, Sololá, and Suchitepéquez); Honduras (Atlántida, Colón, Comayagua, Copán, Cortés, El Paraíso, Francisco Morazán, Intibuca, Ocotepeque, Olancho, and Santa Barbara); Nicaragua (Boaco, Chontales, Estelí, Grenada, Jinotega, Madriz, Managua, Matagalpa, Nueva Segovia, and Zelaya); and Panama (Chiriquí and San Blas) (Macqueen 1992, Macqueen and Hernández 1997).

Calliandra calothyrsus is a fast-growing shrub or small tree. The trees can attain a height of approximately 3 m in the first year of growth and may reach heights of 12 to 15 m, with either a single stem or many stems. In wetter environments, the species is characterized by trees of larger stature (up to 15 m tall) with red-brown to dark brown bark and angular young shoots tinged with red. In drier environments, the trees are generally smaller (between 2 and 10 m tall) and possess pale gray to light brown bark. *Calliandra calothyrsus* occurs in primary, secondary, or disturbed, lowland to premontane, dry to wet subtropical forests, especially along river and road margins, and in fallow fields. It is tolerant of medium shade, and occurs on a range of (often acid) soils (alluvial deposits, clays, and sandy loams) of various depths. *Calliandra calothyrsus* is not tolerant of frost, requiring a mean annual temperature of 22 to 28 °C, and inhabits areas with an annual rainfall of 1000 to 4000 mm at altitudes between 0 and 1850 m.

Calliandra calothyrsus is one of seven species in a subgroup of the genus, series *Racemosae*, which all typically display allopatric distributions. Sympatry does exist between *C. calothyrsus* and *C. houstoniana* (Mill.) Standl., *C. houstoniana* and *C. grandiflora* (L'Hér.) Benth., and *C. houstoniana* and *C. juzepczukii* Standl. Sympatry does not, however, always lead to hybridization, and putative hybrids have been documented only between *C. calothyrsus* and *C. houstoniana* and between *C. houstoniana* and *C. juzpeczukii* (Chamberlain 1996, Macqueen and Hernández 1997). Natural hybrids appear to be relatively uncommon, however, and are likely to have arisen through the disturbance of previously isolated habitats rather than through reproductive isolation (Chamberlain and Hubert, 2001). Interspecific hybrids between *C. calothyrsus* and *C. houstoniana*, which are predominantly infertile, have been observed, although the perfect floral structure of hybrids produced artificially castes some doubt on the occurrence of widespread hybrid infertility in the *Racemosae*.

Substantial ecotypic variation has been observed within *C. calothyrsus* (Chamberlain and others, n.d.). The analysis of isozyme and RAPD molecular markers has provided evidence for the existence of four subgroups within the species (*C. calothyrsus-1* to *-4*) (Chamberlain 1998, Hubert 1997). Distinct morphological variation was found to parallel the observed variation in molecular markers, and differences in environment (geographical location, altitude, rainfall) were, in turn,

associated with particular combinations of molecular and morphological variation, lending support to the description of ecotypes within the species (Chamberlain and others, n.d.).

Calliandra calothyrsus is cultivated and used widely for fuelwood, animal fodder, green manure, shade for tea and coffee, and soil conservation in many parts of the humid tropics (Macqueen 1992, National Research Council 1983a). The species, introduced to Indonesia from Guatemala in the 1930's (Verhoef 1939), is now naturalized in many parts of Java. Until recently, these naturalized populations have been the major source of seeds for planting in southeast Asia, Australia, and east and west Africa. In Indonesia, the species has been cultivated primarily for afforestation, soil conservation, and as a bee forage in honey production, although trees are often cut or coppiced for fuelwood (Kartasubrata 1996). In other exotic environments, the species is an important source of forage for cattle and goats, in terms of both research and cultivation, e.g., in Queensland, Australia, and Embu, Kenya (Palmer and Ibrahim 1996, Paterson and others 1996b). *C. calothyrsus* is rarely used in its native range, however; possibly a combined result of relatively low population pressure on the land, the region's high diversity of other useful woody species, and poor promotion of the species through regional research establishments (Arias and Macqueen 1996).

Calliandra calothyrsus has a flowering period that can extend up to 12 months per year if sufficient soil moisture is available. Across the native range, flowering reaches a peak during October and November and ceases where a pronounced dry season is experienced (January to April). The inflorescence of *C. calothyrsus* is a paniculate raceme in which the flowers open acropetally over 60 to 90 days. The flowers are held within subumbels and the number of flowers open per subumbel ranges from 4 to 14 (Macqueen 1992). The flowers are characterized by their long, red or pink, staminal filaments, which form the brush-type floral display typical of many mimosoid legumes. From pollination to seed maturity, a period of between 90 and 120 days is required, but sequential flowering means there will almost always be a proportion of seeds on a tree that are not ripe. The fruits, flattened pods with thickened and raised margins, change color from green to golden or dark brown as the seeds reach maturity. When ripe, the pods split from the apex to the base, scattering seeds for short distances (up to 10 m) from the parent plant (Macqueen 1992).

Between-population variation for flower production, floral phenology, total pod production, number of seeds per pod, and number of aborted seeds per pod has been found in *C. calothyrsus* (Rajaselvam and others 1996). Such variation will inevitably have an impact on the timing of seed collection and the number of visits needed to acquire appropriate quantities of seed. The explosive dehiscence of pods means that accurate timing is required for efficient seed collection. According to Macqueen (1992), pods should be collected when fruit maturation is relatively constant and the majority of trees within the collection area have set seed. If there are only a few trees, or flowering and subsequent fruiting between trees has been asynchronous, seed collection may continue over several weeks.

A number of methods are used to collect fruit of *C. calothyrsus*. Collectors use long-arm pruners to cut off the inflorescence axes bearing mature fruit (Macqueen 1993b) or branches are bent down and the pods removed by hand. In seed production orchards, sacking can be placed on the ground below the *C. calothyrsus* trees, and the pods left to dehisce naturally. This method ensures that all of a tree's mature seeds are collected and labor inputs are relatively small (Hopkinson, personal communication). In natural populations, no more than 75 percent of the pods have been collected from individual trees to ensure that sufficient seeds are left to regenerate the stand (Macqueen 1992). Because pods are usually collected at the beginning of the dry season, in both the native range and exotic environments, sun-drying of both pods and seeds is often possible. The separation of seeds from pods is best achieved through slow, natural drying. Pods may be placed in wire mesh containers in the sun, and the wire mesh will then trap the seeds as the pods dehisce. The manual opening of pods has been generally avoided because the seeds may be immature and could undergo overly rapid and potentially deleterious drying on exposure to the air. Once pods are open, seeds can be thrashed out from the pod waste and cleaned manually or mechanically. At this stage, it is important to dry the seeds to between 6 and 10 percent moisture content by placing them on drying mats under warm, dry conditions without prolonged exposure to direct sun. For interim storage, the dry seeds can be placed in labeled, ventilated, canvas bags.

Seed predation by bruchid beetles (e.g. *Stator limbatus*) has been virtually nonexistent in some populations of *C. calothyrsus*, but has been found to affect 85 percent of the total seed harvest from other populations (Johnson and Lewis 1993, Macqueen 1993b). Low-temperature storage is an effective way of killing any developing beetles.

Seed moisture content and temperature are critical to successful long-term storage of *C. calothyrsus*. Seeds are orthodox and can be stored at 4 °C for periods of more than 5 years with a percentage germination of 75 to 90 percent. Airtight metal tins will protect the seeds from external changes in humidity and prevent insect and fungal attack. Problems with seed viability in *C. calothyrsus* have sometimes been reported (e.g. Roshetko and others 1996), and Macqueen (1995) emphasizes the need to collect mature seeds and reduce the time between collection in the field and storage under cool, dry conditions.

Calliandra calothyrsus germinates readily without pretreatment, especially when fresh seeds are used. Nevertheless, making an incision in the seedcoat (nicking) may improve germination. Verhoef (1939) reported that the germination rate increased from 28 to 48 percent (untreated) to 94 to 97 percent (with nicking). Halliday and Nakao (1984) also found scarification improved germination. Macqueen (2001) has suggested that situations where labor constraints make the individual nicking of seeds unjustifiable, a 10-minute soak in hot water (70 °C) followed by a 12- to 24-hour soak in cold water is the preferred pregermination treatment.

Calliandra calothyrsus is nitrogen-fixing, and the growth of the species is greatly improved by inoculation with *Rhizobium* (Lesueur and others 1996a). *Calliandra calothyrsus* was scarcely, or not at all, nodulated by strains from the genus *Bradyrhizobium* (Lesueur and others 1996a). Inoculation with a known strain of *Rhizobium* has, therefore, been recommended when introducing *C. calothyrsus* to exotic environments for the first time. Macqueen (1993a), in conjunction with the Nitrogen Fixation by Tropical Agricultural Legumes Center (NifTAL) in Hawaii, recommended and supplied strains for use in the *Calliandra* provenance trial network. Alternative strains have been identified by Lesueur and others (1996a, 1996b).

Rhizobium inoculum is stored in sterile dry peat, and must be kept sealed and refrigerated in a dark room, then used within 6 months. Inoculum can be applied as a coating to the seed using 50 g of inoculum per kg of seed. Applications of 1 ml liquid per 50 g of seed can be made using vegetable oil, a solution of 40 g gum arabic in 100 ml water, or 1 part sugar to 2 parts water (Nitrogen Fixation by Tropical Agricultural Legumes Center 1984). Alternatively, a slurry of 5 g inoculum mixed with water can be applied directly to 1,000 seedlings (Macqueen, 2001).

Another important soil association occurs between roots of *C. calothyrsus* and vesicular-arbuscular mycorrhizal fungi (VAM). Reena and Bagyaraj (1990) found that when *C. calothyrsus* was inoculated with *Glomus velum* and *Glomus merredum* (VAM fungi), the inoculated plants had greater height, leaf number, stem girth, biomass, and phosphorous and zinc content than uninoculated plants. Macqueen (2001) has recommended that when preparing land for *C. calothyrsus* cultivation, the duration of any preceding cultivation of crops without mycorrhizal associations should be minimized to avoid reduction in the land's VAM inoculation potential (Shepherd and others 1996). Direct inoculation with VAM may also provide benefits.

Calliandra calothyrsus can be propagated by seeds sowed directly at the planting site, or raised in the nursery as container seedlings or bare root seedlings. Selection of the propagation technique will depend on the planting objectives and the planting environment (e.g., soil fertility, rainfall, available resources, labor, and transport constraints). Because propagation techniques for *C. calothyrsus* have been reported in detail elsewhere (e.g., Macqueen 1993b, Roshetko and others 1997), a standard propagation method under nursery conditions is summarized. After inoculation with *Rhizobium* and VAM fungi, two seeds are sowed in a 10 cm by 20 cm standard black polyethylene container and the second seedling removed after its first adult leaves begin to show. The seedlings are then placed under 50-percent shade, which is gradually reduced before planting. The containers can be lifted occasionally to allow root pruning. When the seedlings are 20 to 50 cm tall with a root collar diameter of 0.5 to 1 cm they can be planted immediately after the first heavy rains. Young seedlings should be protected from fire, pests, weed competition, and browsing animals.

ADDITIONAL INFORMATION

Floral anthesis occurs between 1530 and 1700 hours and is followed by anther dehiscence once the flowers are fully open. The stigma are receptive from 1900 hours on, but by 0600 hours the following morning, receptivity has been lost and the flowers begin to wilt. Pollination is effected by nectivorous bats and sphingoid moths (Chamberlain and Rajaselvam 1996, Hernández 1991).

Range-wide provenance seed collections of *C. calothyrsus* have been made by the Oxford Forestry Institute with the aim of maximizing genetic diversity within the final collection (Macqueen 1991, 1993b). The seeds have been used to evaluate the diversity of the species within replicated field trials across a range of environments in terms of growth and biomass accumulation (Pottinger 1996). Based on the species' reproductive biology and ecology, Macqueen (1992) recommended the collection of seeds from at least 50 individuals within a particular provenance, spaced at distances greater than 100 m. Actual collections were from between 8 and 65 individual trees (most commonly between 20 and 50) spaced at a minimum of 50-m intervals depending on available population sizes and densities in the native range (Macqueen 1993b). The presence of root suckering in one provenance from Honduras meant that adjacent plants were genetically identical, highlighting the need to collect from well-spaced individuals. Random selection of trees for seed collection was preferred, i.e., individual trees were not selected on the basis of their phenotypic form, to ensure that a wide spectrum of genotypes was included within the seed collection and the subsequent evaluation program.

Sympatry in the *Racemosae* and the occurrence of putative *Calliandra* hybrids has important implications for the genetic integrity of seeds collected from populations of *C. calothyrsus*. Chamberlain and others (n.d.) recommend that *C.*

calothyrsus seeds always be collected from large stands that are isolated from any other *Calliandra* species. Macqueen (1995) suggests that particular care should be taken when collecting *C. calothyrsus* seeds from naturalized stands in exotic environments. As much information as possible should be gathered about the stand from which seeds will be collected, especially whether the trees were established with seeds from a single parent or from a bulk collection, etc.

Measurements from a number of populations from within the native range found that mean seed ovule ratios vary from 0.83 to 0.65 per pod per population (Chamberlain, n.d.; Hernández 1991; Macqueen 1993b). Mean ovule number varied from 9.12 to 6.70, and mean seed number per pod varied from 6.65 to 5.59. Quantities of seeds per tree are generally low (averaging about 100 g per tree, equivalent to approximately 1,400 to 1,700 seeds; Macqueen 1993a, National Research Council 1983a). Low quantities of seeds per tree are normal for the species, although such figures are often smaller than for those of comparable agroforestry trees. Therefore, such small quantities of seeds per tree should not be interpreted as a seed production problem when the species is introduced to exotic sites (Boland and Owour 1996, Chamberlain and Rajaselvam 1996).

2cm
1cm
1cm