2.4 Calliandra calothyrsus - a Multipurpose Tree Legume for Humid Locations

B. Palmer, D.J. Macqueen and R.C. Gutteridge

Introduction

Calliandra calothyrsus Meissn. (calliandra) is a small, thornless leguminous tree native to Central America and Mexico. It is rarely utilised in its native range but it has been introduced to many tropical regions where it is used in agroforestry systems for fuelwood, plantation shade, as an intercrop hedgerow and more recently as livestock forage.

It is particularly favoured in Indonesia where over 170,000 ha have been planted for reforestation of eroded, poor quality land around villages (NAS 1983).

This section describes the species, its origin, ecology, agronomy and some of its many uses throughout the tropics.

Taxonomy

Systematics

There is confusion regarding the taxonomy of the genus *Calliandra* due to the morphological similarity of *C. calothyrsus* to *C. grandiflora* and *C. houstoniana,* and the observed hybridisation between the latter species (Hernandez 1991). *Calliandra calothyrsus* Meissn. is one of seven species in a subgroup of the genus, the Racemose delimited by Bentham (1844) and belonging to the family Mimoseae. *Calliandra calothyrsus* was described by Meissner (1848) and the later names *C. confusa* and *C. similis* have now been placed in synonymy. *Calliandra acapulcensis,* the closest relative of *C. calothyrsus,* is now considered to be only a subspecies extending its known range to Colima in Central Mexico.

Botanical description

Calliandra calothyrsus Meissn. is a small tree (2-12 m high), with a trunk diameter of up to 30 cm, with white to red brown bark and a dense canopy. Leaves are bipinnate and alternate; the rachis is 10-19 cm long, without glands; pinnae are (3)-6-20 jugate; rachilla are 2-11 cm long; there are 19-60 pairs of leaflets; leaflets are linear, oblong and acute, 5-8 x 1 mm. Inflorescences are particulate with flowers in umbelliform clusters of 10-30 cm length. Flower sepals and petals are green, calyx 2 mm long, corolla 5-6 mm long. The numerous red stamina! filaments are 4-6 cm long. Fruits are broadly linear, flattened, 8-11 cm x 1 cm linear oblong with thickened and raised margins, finely pubescent or glabrous, brown dehiscent, 8(12) seeded. Seeds are ellipsoid, flattened, 5-7 mm long and mottled dark brown (Weirsum and Rika 1992) (Figure 2.4.1).

Origin and Geographic Distribution

The plant is native to the humid and subhumid regions of Central America and Mexico and is found from southern Mexico to Central Panama, approximately between 8°and 19°N (Macqueen 1992). It was introd uced from Guatemala to Java, Indonesia in 1936 (Verhoef 1939) as a possible source of green manure and shade for coffee plantations and is now found throughout the Indonesian archipelago. During the 1970s, sponsored by the Indonesian State Forest Corporation, *C. calothyrsus* was planted in many areas of Java and elsewhere in Indonesia in what has been termed 'a true self perpetuating greening movement'.

More recently it has been introduced to other areas of southeast Asia and is also under experimental evaluation in Africa, Australia, Brazil, Bolivia and Hawaii.

Ecology

Calliandra calothyrsus is a riverine colonist with relatively rapid early growth. It is outcompeted in later successional stages but may often invade areas of continual disturbance such as roadsides or shifting cultivations. In its native Central American habitat, it grows at altitudes from sea level to 1,860 m in areas where the annual precipitation ranges from 700 to 3,000 mm (Lowry and Macklin 1989). The plant is not very drought tolerant although it is able to withstand dry periods. In humid climates, the tree is evergreen, whereas in areas with a long dry season it is semi-deciduous. Under severe drought conditions, the tree will die back but will generally recover after the onset of the rainy season although Akkasaeng *et al.* (1989) reported only 20% survival of *C. calothyrsus* after 30 months in a monsoonal environment in northeast Thailand.

Fig. 2.4.1. Leaves, flowers and pod *of Calliandra calothyrsus.*

Pollination is achieved in the native range by hawkmoths and bats of the genus *Glossophaga.* Protandrous flowering and the difference in length between stigma and style suggest outcrossing. Pod ripening is basipetal over several months and seed dispersal is through apical dehiscence of the pods.

Calliandra calothyrsus grows well on a wide range of soil types ranging from deep volcanic loams to more acidic metamorphic sandy clays. It appears naturally well suited to the light textured slightly acidic soils of volcanic origin which are common to the humid and subhumid tropics of southeast Asia. The precipitation pattern in these areas shows a well defined wet and dry season and an annual rainfall of 2,000-4,000 mm. The plant is not tolerant of low oxygen tensions in waterlogged situations (Galang 1988) and does not grow well on poorly drained calcareous soils.

Within its native environment, *C. calothyrsus* occupies areas with mean monthly maximum temperatures between 24 and 28°C and mean m inimum temperatures of 18-24°C (Wiersum and Rika 1992). These areas are fr ost free but *C. calothyrsus* appears to have some cool tolerance since it grows up to 1,800 m in Guatemala.

It is thought that the introduction of *C. calothyrsus* to Indonesia in 1936 was based on only two seed samples from Guatemala (NAS 1983). This accounts for the lack of variation in the Indonesian material. The evaluation of a range of provenances is therefore desirable and the species has now been collected by the Oxford Forestry Institute at over 40 sites from seven countries in Central America covering a large range of edaphic and climatic regimes. A programme to evaluate these provenances is underway and seed is available on request (Macqueen 1991, 1992).

Agronomy

Calliandra calothyrsus does not take well from stakes and is therefore best propagated from seed in the field or raised in a nursery. Seeds germinate without pre-treatment, but considerable improvement has been obtained after mechanical scarification (Verhoef 1939, Halliday and Nakao 1984). Caution should be exercised when using hot water treatment to improve germination as the seed appears more sensitive than seed of other tree legume species and some failures have resulted. It is commonly stated that inoculation with *Rhizobium* is not necessary (Zhou and Han 1984) but use of an appropriate strain is advised when introducing the plant to new areas.

Calliandra calothyrsus, like many other tree legumes, often displays slow early growth (Evans 1984, Glover and Heuveldop 1985, Jama *et al.* 1989). This may be linked to poor or ineffective mycorrhizal associations (B. Palmer, unpublished data). However, once it is mycorrhizal, *C. calothyrsus* grows quite vigorously and can achieve a height of 3.5 m in 6 months (Wiersum and Rika 1992). This rapid growth allows the plant to be used as a smother crop in *Imperata cylindrica* infested areas.

While there are no reports of serious pest or disease problems some insects may cause minor damage. Nair (1982) reported seedlings of *C. calothyrsus* attacked by the teak sapling borer (*Sahyadrassus malabaricus*), while in Kenya, *Pachnoda*

the teak sapling borer (*Sahyadrassus malabaricus*), while in Kenya, *Podisoma ephippiata* feeds on the flowers, fruits and foliage causing floral abortion and poor seed production (Kaudia 1990) (Section 6.3). If the plants are coppiced too low immediately prior to rain, or during the wet season, they may be susceptible to fungal attack. This problem is, however, common to most shrubs and trees. Seed production may commence in the first year but usually the plant fruits well only after the second year (Section 3.6).

The use of fertiliser, particularly on infertile soils, will improve the early growth and yield of *Calliandra,* but it is less responsive to fertiliser than some other tree legumes and will often outyield other species on infertile soils. Palmer *et al.* (1989) found this when comparing the growth of *C. calothyrsus, Leucaena leucocephala* and *Gliricidia sepium* at two sites in Indonesia and at two sites in Australia (Table 2.4.1).

However, on more fertile, less acidic soils, yields of *C. calothyrsus* were similar to those of other species. On a Typic Humitropept derived from basalt in Western Samoa, *C. calothyrsus* and *G. sepium* gave similar biomass dry matter yields of approximately 10 t/ha/year in 4 m alleys over 4 years (Rosecrance *et al.* 1992b). In Hawaii, in an experiment to evaluate nine leguminous trees for alley cropping, *C. calothyrsus* yielded 4.3 t/ha and was fifth behind *Sesbania sesban, G. sepium, Leucaena pallida and Cajanus cajan* in yield (Rosecrance *et al.* 1992a).

Uses

The uses of calliandra have been detailed in a number of publications including NAS (1983), Lowry and Macklin (1989), Wiersum and Rika (1992) and Macqueen (1992). In its native area, it was unused and it was not until it was introduced into Indonesia that its potential value and multipurpose uses became apparent.

The common uses of *C. calothyrsus* are as follows:

- firewood,
- fodder,
- reforestation,
- soil stabilisation,
- soil improvement,
- minor secondary production (pulp and paper, honey and shellac, leaf meal).

Table 2.4.1. Soil parameters and annual leaf yield (t/ha) of three tree legumes at four sites with and without fertiliser application (after Palmer *et al.* 1989).

		Cation exchange capacity (meq/100 g)	*C. calothyrsus*		*G. sepium*		*L. leucocephala*	
Sites	**pH**		**Fertiliser application***					
			-	+	-	+	-	+
(a) Fertile sites								
Utchee Creek (Australia)	5.3	2.39	11.3	12.6	7.8	7.8	5.5	7.3
Sei Putih (Indonesia)	5.3	2.69	6.6	11.8	5.2	7.5	4.0	7.5
(b) Less fertile sites								
Silkwood (Australia)	5.3	0.83	3.0	7.7	1.5	5.2	0.4	3.1
Sembawa (Indonesia)	4.9	0.87	2.3	6.8	1.1	3.1	0.5	2.1

* The fertiliser treatment was an application of 33 kg P, 20 kg Mg, 3 kg Cu, 3 kg Zn, 0.2 kg Mo, 1.5 kg B and 2 t lime/ha (at Sembawa and Silkwood) or 0.4 t lime/ha (at Sei Putih and Utchee Creek)

Firewood

The wood of *C. calothyrsus* has a volumetric mass of 510-780 kg/m^3 and a calorific value of about 4,720 kcal/kg (Yantasath *et al.* 1985, Lowry and Macklin 1989). It is therefore a good fuelwood. The moisture content of calliandra wood (9-12%) is lower than that of other woods (e.g. leucaena 13.5%) and hence less drying is needed. The wood is suitable for charcoal production and as a smoking fuel for the production of smoked sheet rubber. There is a demand for smoking fuel since old rubber trees, the traditional source, are increasingly used by furniture manufacturers. Annual wood yields have been reported in the order of 15-40 t/ha with annual coppice harvests continuing for 10-20 years (Wiersum and Rika 1992).

Fodder

In Indonesia, annual forage yields of *C. calothyrsus* in the order of 7-10 t/ha of dry matter have been recorded over a wide range of edaphic and climatic zones (Ella *et al.* 1989). Kidd and Taogaga (1984) reported fresh fodder yields of up to 46.2 t/ha/year from Western Samoa.

There are varying reports on the acceptability of *C. calothyrsus* to domesticated animals in Indonesia. However, it appears to be readily eaten by animals although only limited information is available on its nutritional value. It is routinely fed to goats on the islands of Java, Sumatra, Flores and Sumbawa and to dairy cattle in West Java, where the animals readily eat the fresh herbage. In several experiments in Australia, calliandra has been shown to be highly palatable for both grazing and pen-fed animals (B. Palmer, unpublished data). However, Raharjo and Cheeke (1985) reported that its palatability to rabbits was low. Wiersum and Rika (1992) reported 22% crude protein, 30-70% fibre, 4-5% ash and 2-3% fat in dried leaves of *C. calothyrsus.* No toxic substances have been found but high concentrations of condensed tannins (up to 11%) have been reported (Akin *et al,* 1989). These levels may be responsible for the rather low (around 40%) *in sacco* digestibilities measured on oven-dried material in a number of experiments (Baggio and Hueveldop 1984, Robertson 1988). An advantage of the tannin is that it ensures protected (bypass) protein but high levels of tannin may reduce the digestibility of protein for livestock.

However, recent work in both Australia and Indonesia has indicated that forage of *C. calothyrsus* may have higher value when fed fresh. When leaf material of *C. calothyrsus* was fed fresh to sheep, voluntary intake was 59 g dry matter/kg $W^{0.75}$ whereas for dried material it was 37 g dry matter/kg $W^{0.75}$ ($W^{0.75}$ is the metabolic weight of the animal). The higher level of voluntary intake was associated with a higher *in sacco* digestibility of fresh material compared with oven-dried or freeze-dried material (Palmer and Schlink 1992). In feeding trials conducted in Indonesia with both goats and sheep, the in vivo estimates of digestibility were in the order of 60% (Mahyuddin *et al.* 1988). These data suggest that the nutritive value of *C. calothyrsus* is not yet fully understood, but the high digestibility of fresh material (60-80%) shows the potential of calliandra as a feed for browsing animals (Palmer and Schlink 1992).

Reforestation and soil stabilisation

Calliandra calothyrsus has been used to rehabilitate erosion prone areas such as recently cleared forests and steep slopes with high erosion risks (Kan and Hu 1987). The combination of a deep and well developed lateral rooting habit provides a structure to stabilise the soil.

Furthermore, it has been reported from Indonesia that it can be aerially seeded

Furthermore, it has been reported from Indonesia that it can be aerially seeded successfully. This could be a strategy for the reforestation of mountainous or otherwise inaccessible terrain (NAS 1983).

Soil improvement

Calliandra calothyrsus as a nitrogen fixing tree has been used as a green manure to improve the fertility status of soil in rotation with sugar cane and in alley cropping with corn (Gichuru and Kang 1989). Calliandra produces high yields of high protein leaf material on less fertile soils and is therefore very suitable as a green manure. However, the relatively high levels of polyphenols (tannins) present in the leaves of calliandra slow the rate of microbial breakdown of the organic matter reducing its value as a soil ameliorant (Gutteridge 1992).

Minor secondary production

Calliandra calothyrsus has proved useful in a number of different ways. It flowers prolifically and is a favoured source of nectar for honey bees. The honey produced is considered to be of exceptionally high quality (Nadiar 1979). It has also been shown to be a suitable host for shellac producing insects. As an additive to leaf meal it has shown promise both as a protein source and as a source of carotene to maintain yolk colour in commercially produced eggs.

Conclusions

Calliandra calothyrsus is a versatile plant being used in a number of agroforestry applications throughout the tropics. It produces high quality fuelwood which can be harvested on an annual coppice rotation. It grows over a wide range of soil types and is often outstanding on infertile sites where it is used extensively for reclamation.

Its high yielding ability and high protein content indicate its potential as a valuable forage source. However, it has not been widely accepted in this role partly because of the apparent low acceptability of cut forage to stock. Recent studies have shown higher digestibility and intake of fresh forage and further work on the effects of direct grazing of *C. calothyrsus* appears warranted to help determine appropriate management systems for this potentially useful forage species.

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