Trichanthera gigantea (Humboldt & Bonpland.) Nees: A Review

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Introduction

Trichanthera gigantea is a tree of the Acanthaceae family and is apparently native to the Andean foothills of Colombia, but is also found along streams and in swampy areas from Costa Rica to northern South America (McDade, 1983) and in wet forests from Central America to Peru and the Amazon basin, being also fairly common on certain islands in the Amazon estuary (Record and Hess, 1972).

It is a very promising fodder tree for a wide range of ecosystems. Its range has been reported from 0 to 2,000 (Murgueitio, 1989), 800 to 1,600 (Acero, 1985), and from 500 to 1,800 metres above sea level (Jaramillo and Corredor, 1989). It is well adapted to the humid tropics with an annual rainfall between 1,000 to 2,800 mm (Acero, 1985., Jaramillo and Corredor, 1989), but it has been found growing in the Cocho region with an annual rainfall between 5,000 to 8,000 mm/year (Murgueitio, 1989). It grows well in acid (pH 4.5) and low fertility but well drained soils. It is often found along streams and springs (Acero, 1985).

Taxonomy

Family:	ACANTHACEAE
Subfamily:	ACANTHOIDEAE
Tribe:	TRICHANTHEREAE
Genera:	*Trichanthera*
Species:	*Trichanthera gigantea*

Vernacular names: Aro blanco, nacedero, rompebarriga (Leonard 1951), nacedero (Tolima), quiebrabarrigo (Antioquia), cajeto (Ocaña), fune, madre de agua (Villavicencio) (Colombia); suiban, cenicero, (Bolivia); tuno (Guatemala); naranjillo (Venezuela); palo de agua (Panama); beque, pau santo (Brasil) (Perez-Arbelaez, 1990).

It was first described by Mutis in 1779, who noted the hairy anthers. In 1801, Humboldt and Bonpland thought that this was a species of the genus *Ruellia* and classified it as *Ruellia gigantea* (all species of the genus *Ruellia* are herbaceous). In 1817, Kunt suggested the creation of the genus *Trichanthera* (Trich hair, anthera anther). In 1847, Nees, based on the early descriptions, named the genus *Trichanthera* (Perez-Arbelaez, 1990). In 1930, Leonard described a new species, *Trichanthera corymbosa*, from a specimen collected in Norte de Santander, Colombia and ascribed it to the north east of Colombia and Venezuela. So far, these two species and one variety, the British Guiana form *Trichanthera gigantea* var. *guianensis* Gleason (Record and Hess, 1972), have been described in the *Trichanthera* genus.

Key to the species:
Calix lobes rounded; inflorescence racemose, secund: *T. gigantea*
Calix lobes obtuse or acute; inflorescence corymbose: *T. corymbosa*

Description

Shrubs or trees (sometimes bushy and bearing adventitious roots) up to 5 metres high (a height of 15 metres witvih a trunk diameter of 25 cm has been reported from Colombia (Record and Hess, 1972)), the top rounded; branches quadrate, the angles rounded, the tips minutely brown-tomentose; lenticels prominent; leaf blades ovate to oblong, up to 26 cm long and 14 cm wide, acuminate at apex, narrowed at base, glabrous, or the costa and veins pubescent; petioles 1 to 5 cm long; inflorescence a terminal compact more or less secund panicle 5 to 15 cm long and 4 to 5 cm broad, brown-tomentose; bracts triangular, 3 mm long; calyx 10 to 12 mm long, brown-tomentose, the segments 7 to 10 mm long, 5 mm wide, rounded at apex; corolla 3 to 4 cm. long, red and glabrous proximally, yellowish and silky-tomentose distally, red and glabrous within, the tube 1 to 1.5 cm long, the limb 2 to 3 cm. broad, the lobes oblong to oblong-ovate, 3 to 5 mm wide; ovary tomentose; style 4 to 5 cm long; capsule 1.5 to 2 cm long, obtuse at apex, silky-pubescent, the hairs closely appressed; retinacula 3 mm long, curved, truncate and erose at tip; mature seed 1 to 4 in each capsule, lenticular, 3 to 4 mm broad, glabrous (Leonard, 1951).

Its wood has about the consistency of Red Maple (*Acer rubrum*). The pith is large and septate (Record and Hess, 1972).

Like all acanthaceous plants, *Trichanthera* has cystoliths, small mineral concretions appearing as minute short lines on the upper surface of the leaf blades, the upper portions of the stems, on the branches of the inflorescence and on the calyx (Leonard, 1951).

Traditional Uses

It had been used by the campesinos in Colombia as a medicinal plant to cure colic and hernia in horses, retained placenta in cows and intestinal obstructions in domestic animals (Perez- Arbelaez, 1990., Vasquez, 1987). Medicinal properties for humans have been also attributed to it. Its green stems are used to cure nephritis and its roots as a blood tonic. Its sprouts are used in maize porridge for human consumption (Vasquez, 1987). In some regions it is used as a lactogenic drink for nursing mothers (Ruiz, 1992). It has also been used as a fodder plant and as a live fence, for shade and for protection of water springs (Perez-Arbelaez, 1990., Devia, 1988., Gowda, 1990).

Reproduction and Propagation

In Panama, McDade (1983), by bagging the flowers prior to anthesis, demonstrated that the flowers do not self-pollinate as none of the stigmas of bagged flowers had any pollen grains. Other experiments shown that at least eight grains of pollen are necessary for fruit set and that mean seed set per fruit is very low (less than one of a maximum of eight), suggesting that pollination limits seed production by this species at this site. In Colombia, one species of bat, *Glossophaga soricina*, and several species of hummingbirds, ants and large bees have been observed visiting the flowers of *Trichanthera* from early to mid afternoon, when the anthesis occurs (Perez-Arbelaez, 1990., Gomez and Murgueitio, 1991). In the Cauca valley in Colombia, Acero (1985) reported the following characteristics of seeds and fruits: number of seeds/kg: 4,050,000; fruits/kg: 1,123; and seeds/fruit: 35 - 40. It has been reported that seeds do not germinate or are difficult to germinate (Acero, 1985., Murgueitio, 1989., Gowda, 1990). The percentage germination of the seeds has been found to be very low, from 0 to 2% (CIPAV, 1996).

Mangrove plants or mangroves (as distinct from mangrove communities or mangals) can be defined as tropical or subtropical ligneous plants that occur in intertidal and adjacent communities. Such plants exhibit various adaptations (e.g., aerial roots in many) to their environment. *Trichanthera gigantea* often has prop roots. It may eventually be shown to occur as a mangrove as well. Mangrove trees are not currently known among other Latin American genera of the Acanthaceae family (Daniel, 1988). The mature stems close to the ground, have the capability to form aerial roots that, when in contact with the soil, give rise to a new plant (Gomez and Murgueitio, 1991).

The propagation of this species by campesinos has been carried out using stakes, as these are easy to grow and it avoids the problems of scarcity of seeds and difficulty of germination (Gowda, 1990).

The greatest percentage germination (95%) in the tree nursery has been found using sticks 4 cm diameter and 50 cm long (Acero, 1985). In other experiments, a 92% germination was found using sticks from 2.2 to 2.8 cm diameter and 20 cm long, with a minimum of 2 leaf buds. The percentage germination was less then 50% when using bigger sticks from 3.2 to 3.8 cm diameter and from 20 to 30 cm long (Jaramillo and River, 1991).

Mortality during this period has been found to be very low (3%) (Gowda, 1990). The sticks should be obtained from the basal part of the young stems of the tree and kept in a humid and shaded place for one day and then planted in a substrate made of soil, sand and organic matter in proportions 5:1:2. The first leaves appear 27 - 29 days after planting and the trees are transplanted to the fields 50 days after that (Jaramillo and River, 1991., Acero, 1985).

Harvesting and Foliage Production

The first harvest can be made when the trees are 8 to 10 months old, giving production of foliage of 15.6 and 16.74 ton/ha (fresh matter basis) respectively at a density of 40,000 plants/ha (0.5 x 0.5 m. spacing) (Jaramillo and River, 1991). *Trichanthera* is harvested every three months, yielding 17 ton/ha per cutting (0.75 x 0.75 m. spacing) (Gomez y Murgueitio, 1991). Planted as a living fence, *Trichanthera* can yield 9.2 tons/year of fresh foliage per linear kilometre harvested every three months (1 x 1 m. spacing) (CIPAV, 1996).

Yields of fresh foliage of 8 and 17 ton/ha per cutting have been reported when the cutting height was 0.6 and 1.0 m. respectively (Gomez and Murgueitio, 1991). According to CIPAV (1996), the ideal height at cutting is 1.0 m. In regions were the temperature is high and precipitation low, better results are achieved by cutting at a height 1.3 to 1.5 m. Total biomass production (fresh foliage and young stems) has been calculated as 53 tons/ha per year (CIPAV, 1996).

Its vigorous regrowth, even with repeated cutting and without fertilizer applications, indicates that nitrogen fixation could occur in the root zone either through the action of mycorrhiza or other organisms (Preston, 1992). Nodules in the root zone were observed suggesting the association with mycorrhiza or other organisms (Gomez and Murgueitio, 1991). Significant populations of mycorrhiza (64 spores/24 g soil) have been reported (CIPAV, 1996). *Trichanthera gigantea* responds almost linearly to nitrogen from urea (up to 240 kg N/ha per year. The optimum level appears to be 160 kg/ha per year (Nguyen and Phan, 1995).

Nutritive Value

The chemical composition of the leaves and stems of *Trichanthera gigantea* is summarized in Table 1. The thin stems are included as they are also consumed by the animals. The crude protein content of the leaves varies from 15 to 22% and apparently most of this is true protein. The calcium content has been found to be particularly high compared to other fodder trees (Rosales and Galindo, 1987., Rosales *et al.*, 1992). This can be explained by the presence of cystoliths in the leaves, characteristic of the Acanthaceae family, as described above. This can explain the use that the campesinos in Colombia make of *Trichanthera gigantea* as a lactogenic drink and suggests a good potential for feeding lactating animals.

In a qualitative screening test (biochemical preliminary test) for anti-nutritional compounds, no alkaloids or condensed tannins were found in *Trichanthera* and the saponin and steroid contents were low. In other, more precise tests the contents of total phenols and steroids were found to be 450 ppm and 0.062% respectively (Rosales *et al.*, 1989). The great variation in its total phenol content, from 450 to 50,288 ppm (Table 1), has been suggested as the cause of the variation in its nutritional value. The degradability of *Trichanthera* has also been determined (see Table 2).

More recently a more complete characterisation of the nutritive value of *Trichanthera gigantea* has been accomplished. Results are shown in Table 3.

Analysis of its carbohydrate fraction revealed that this plant had the greatest amounts of water soluble carbohydrates, total and reducing sugars when compared with other fodder trees and shrubs. It also showed a surprisingly high amount of starch and its neutral detergent fibre was found to be the lowest. The high amounts of non-structural and storage carbohydrates, combined with the low amounts of structural carbohydrates, may explain the good biological results found with monogastrics. Results in Table 3 show only the presence of phenols with great capacity to react with protein. No condensed tannins were found (tests included a characterisation of phenolic peaks by means of a spectrophotometer). This suggests that tannins from *Trichanthera* may be of the hydrolysable type.

The protein in the leaves has a good amino acid balance as illustrated in Table 4. These results were compared to the amino acid contents of Azolla spp. by Preston (1995). It was found that although the amino acid composition of *Azolla* was slightly better, both had an excellent balance of amino acids, better than that of soya bean.

Table 1: Chemical composition (g/kg) of *Trichanthera gigantea* (on dry matter basis).

	DM	Crude Protein	True Protein	Ash	Crude Fibre	NDF	Ca	P	K	Mg	Total phenols (ppm)
Leaves											
	-	152.5	-	-	-	-	38.0	2.6	31.8	11.4	450a
	200	179.3	-	-	-	-	23.4	3.7	37.6	7.5	- b
	-	166.2	141.3	167	167	-	-	-	-	-	- b
	-	150.9	-	-	-	-	-	-	-	-	22,200c
	224	169.3	-	-	-	-	24.0	3.8	24.2	9.0	50,288d
	269	225.0	-	171	-	297	-	-	-	-	- e
	-	182.0	-	199	183	-	43.0	9.2	-	-	- f
Leaves and Young Stems											
	191	223.0	-	220	440	-	-	-	-	-	- e
Stems											
	-	11.9	-	313	300	-	64.0	2.1	-	-	- f
Thin Stems											
	170	86.7	-	-	-	-	26.1	4.2	69.6	7.2	- b
Thick Stems											
	270	46.25	-	-	-	-	21.9	3.6	38.0	4.8	- b

Sources:
a Rosales *et al.*, 1989; b Gomez and Murgueitio, 1991; c Jaramillo and River, 1991; d Rosales *et al.*, 1992; e Solarte, 1994; f Nhan, *et al.*, 1996

Table 2: *In sacco* degradability of *Trichanthera gigantea* (on dry matter basis).

	In sacco degradability %			
0	12h	24h	48h	72
Leaves				
-	52.4	70.0	77.2	-a
-	52.0	60.0	77.0	-b
-	-	60	-	b

Sources:
a Rosales and Galindo, 1987; b Angel, 1988; c Rosales *et al.*, 1992.

Table 3: Chemical composition (g/kg) of *Trichanthera gigantea* (on a dry matter basis).

Crude protein	178.2
Water soluble protein	35.4
Soluble protein as % of crude protein	19.8
Water soluble carbohydrates	43.2
Starch	
248.2	
Total sugars	170.1
Reducing sugars	91.6
Cell walls (NDF)	294.1
Lignocellulose (ADF)	217.6
Ether extract	31.2
Organic matter	804.1
Protein precipitation activity (cm2/g)	323.5
Condensed tannins (optical density/g)	0
Total phenols (optical density/g)	208.8

Source**:** Rosales, 1996.

The potential fermentability of *Trichanthera* has been assessed by the gas production method. Results showed that the fermentation of this plant species was among the highest when compared to other fodder tree and shrub species. This is related to the high amounts of carbohydrates as shown above (Table 3). Results are shown in Table 5. This is also in agreement with the high rumen degradability if this plant species. In both cases, a very rapid fermentation occurs, illustrated here by the rate of fermentation of the rapidly fermentable fraction. Most of the fermentation occurs during the first 12 hours (see degradability data).

Table 4: Amino acids contents of *Trichanthera gigantea*. Leaves were four months old and growing in 3 different environmental conditions.

	Expressed as g/16gN		Expressed as g/kg leaf	
	Means	SD	Means	SD
Aspartic acid	10.7	0.45	16.4	2.45
Threonine	5.1	0.29	7.8	1.22
Serine	5.1	0.26	7.8	1.10
Glutamic acid	11.9	0.16	18.2	2.36
Glycine	6.1	0.29	9.4	1.44
Alanine	6.2	0.22	9.5	1.42
Valine	6.1	0.19	9.3	1.32
Isoleucine	4.9	0.29	7.5	1.25
Leucine	8.7	0.46	13.3	2.09
Tyrosine	4.0	1.11	6.0	1.14
Phenylalanine	6.0	0.33	9.1	1.55
Histidine	2.8	0.49	4.4	1.29
Arginine	6.5	0.42	9.8	0.90
Proline	5.5	0.38	8.5	1.51
Total Lysine	4.0	0.82	6.0	0.95
Cystine	1.7	0.15	2.6	0.38
Methionine	2.0	0.26	3.0	0.10

Table 5: Gas production kinetics of *Trichanthera gigantea.**

Gas pool size (ml)			218.6
Rate (h^{-1})			
Rapidly fermentable fraction	2.83		
Slowly fermentable fraction		0.20	

*Fermentation carried out for 166 hours according to the Theodorou*et al.* (1994) method.

Source: Rosales (1996).

Feeding Value

In feeding trials with 35-day-old New Zealand rabbits commercial concentrate was substituted with *Trichanthera gigantea* at 10, 20 and 30% levels. The best biological responses were obtained when replacing at the 30% level. At this level the live weight gain was 32.12 g/day and the feed conversion was 4.29 compared with a live weight gain of 32.29 g/day and a feed conversion of 3.49 obtained when concentrate was used alone (Arango, 1990).

Live weight gain of 9 g day and 4.7 feed conversion have been obtained in guinea pigs Cavia porcellus fed with *Trichanthera* foliage, sugar cane juice and 30 g of protein supplement (40% protein) (CIPAV, 1996).

Live weight gain of growing hens fed a diet of maize, earthworms and *Trichanthera* was 8.4 g/day. Those fed with maize, earthworms, soya bean and *Trichanthera* gained 16.8 g/day. The gain of the control group (commercial concentrate) was 17.4 g/day, but this had the highest production costs (CIPAV, 1996).

Pigs eat it well, especially during pregnancy. However, when eaten in amounts that theoretically supply all the protein needs (about 3 Kg/day), pregnant pigs rapidly lost body condition when given only *Trichanthera* as a supplement to sugar cane juice. Up to 30% replacement of the soya bean protein by *Trichanthera* appears to be feasible (Preston, 1995).

Results, in terms of litter size and gain to weaning, from replacing 75% of the soya bean meal with *Trichanthera* in cane juice diets for pregnant sows have been very encouraging. Litter size did not differ from that of the control group and gain to weaning was slightly higher, with high levels of the leaves (Mejia, 1989). In another experiment, leaves from *Trichanthera gigantea* were used as a partial replacement for soya bean (extracted meal or cooked whole seeds) during the pregnancy phase of sows fed a basal diet of sugar cane juice. *Trichanthera* was offered ad libitum and complemented with either soya bean meal or cooked whole soya bean seeds. The control treatment received only cooked whole soya bean seeds as the protein source. There were no significant differences in productive traits (days empty, numbers, weights and growth rate of the piglets) due to treatment. Protein conversion rate (kg protein/kg of weaned piglets) was best on the *Trichanthera*+cooked soya beans (0.425) and worst on the *Trichanthera*+soya bean meal. The control treatment was intermediate (0.608). It is concluded that the leaves of *Trichanthera gigantea* can provide about 30% of the protein (about 1 kg/day of fresh leaves) of the diet of pregnant sows fed cane juice (Sarria, 1994).

Results with growing pigs have been less satisfactory. Performance was reduced at all levels of substitution of soya bean meal by *Trichanthera*. Rate of live weight gain decreased (625, 584, 522 and 451 g/day) and feed conversion deteriorated (3.04, 3.27, 3.63 and 3.89) with increasing substitution (0, 5, 15 and 25%) of soya bean protein by *Trichanthera* leaves. Intake of cane juice, protein and of total dry matter decreased with increasing substitution by *Trichanthera* leaves (Sarria *et al*., 1991).

A cafeteria trial using foliage of *Gliricidia sepium*, *Trichanthera gigantea* and *Leucaena leucocephala* was carried out with weaned lambs (African hair sheep breed) to establish their preference. Relative intakes (kg DM/100 kg live weight/day) were: *Gliricidia sepium* 1.84, *Trichanthera gigantea* 0.73, and *Leucaena leucocephala* 0.19. Results suggested that the factor which most influenced intake of a particular tree foliage was the degree to which the animals were accustomed to eating it and highlighted the need to give the animals an adequate time to adapt to such feeds before they are able to consume appreciable quantities (Mejia and Vargas, 1993).

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