TALL TROPICAL GRASSES AND LEUCAENA AS ENERGY CROPS FOR LOWER SOUTH USA

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ABSTRACT
The tropical leguminous shrub/tree, leucaena (*Leucaena* spp. mainly *leucocephala*), and perennial tropical tall grasses such as elephantgrass (*Pennisetum purpureum*), sugarcane, and energycane (*Saccharum* spp.) are well adapted to the long growing seasons and high rainfall of humid lower South. In much of the area the topgrowth is killed by frost during winter and plants regenerate from underground parts in spring. Selected accessions from a duplicated 373 accession leucaena nursery had an average annual woody stem dry matter production of 31.4 Mg ha^{-1} and four seasons growth of 78.9 Mg ha^{-1}. The tall perennial grasses have linear growth rates of 18 to 27 g $m^{-2}d^{-1}$ for long periods (140 to 196 d and sometimes longer) each season. Oven dry biomass yields of tall grasses have varied from 19 to 45 Mg ha^{-1} in mild temperate locations to over 60 Mg $ha^{-1}yr^{-1}$ in warm subtropics of lower Florida peninsular.

KEYWORDS
Sugarcane, leucaena, elephantgrass, energycane

INTRODUCTION
The humid lower South (Figure 1), located in subtropics and warmer temperate climate zones, has a long warm growing season and high rainfall. Only the humid tropics have a longer growing season and more favorable rainfall for high biomass production. The University of Florida Institute of Food and Agriculture Sciences studied the feasibility of producing methane from biomass energy crops (Smith and Frank, 1988). Elephantgrass also called napiergrass, (*Pennisetum purpureum* Schum.), was found to have great potential as an energy crop (Prine et. al, 1988). With the development in Louisiana of the energycane, L79-1002, (Giamalva et al. 1984), and the high biomass yields reported by Alexander (1985) in Puerto Rico for energycane and sugarcane, (*Saccharum* spp.) we added these to our list of bioenergy crops to be studied. Leucaena, (*Leucaena leucocephala* (Lam.) de Wit), a tropical shrub legume capable of producing high yields of woody stems was also studied. The above crops have cultivars adapted to Lower South and all have the potential of growing for entire warm season with little loss of produced biomass. The accumulated biomass can be harvested during the fall and winter. Regrowth begins the next spring from underground rootstocks.

RESULTS AND DISCUSSION
Elephantgrass. Elephantgrass biomass yields are usually superior to the canes (*Saccharum* spp.)for relative short growing seasons of 5-7 months. The reason is the relative slow early leaf expansion of canes compared to elephantgrass. Elephantgrass begins to make slower growth as it matures and the canes remain at full growth rate and make higher yields in longer growing seasons.

In September, 1982, we selected 11 elephantgrass genotypes showing best growth and planted in a trial replicated four times on the Dairy Research Unit near Gainesville. The average annual biomass yields of the best six genotypes harvested at end of each season for the next five seasons were 32.1, 32.0, 30.5, 28.1, 27.5 and 21.8 Mgha^{-1} for N51, PI 300088, N43, N13, Merkeron and PP3 elephantgrass, respectively.

Miscellaneous Tall Grasses. In 1986, an experiment was planted to compare selected perennial tall grasses with the annual tall grasses, sweet and forage sorghum [Sorghum biocolor (L.) Moench] at 5 locations in the Southeast (Prine et al., 1991). The average annual dry matter yields over the next three years over the five locations are recorded in Table 1. The warmer the environment and longer the growing season the higher the yield of the elephantgrasses, but the L79-1002 energycane gave consistent yields over the 5 locations. The sugarcane CP72-1210, developed for the muck soils south of Lake Okeechobee, did not do well at any of the locations but in the four year period 1987-1990 had an average annual biomass yield of 56.2 Mg ha^{-1} (Stricker, et al., 1996) on phosphatic clay in Central Florida. The high yields of the tall grasses are due to long linear growth periods (140-196 d) at growth rates of 18 to 27 g m^2d^{-1} (Woodard and Prine, 1993).

Leucaena. The average annual oven dry stem yield over 12 leucaena accessions selected from a duplicate single row plot nursery of 373 accessions planted in 1979 at Gainesville FL for four growing seasons was 31.4 Mg ha^{-1} (Table 2). In colder subtropics and warm temperate climates, leucaena is usually killed to ground each winter by freezes and regenerates from underground root stalks. The dead woody stems can be harvested in winter and made into chips for burning or processing into energy products. Twenty accessions of leucaena out of 373 in the nursery had good vigor and/or stands after 12 growing seasons (Cunilio and Prine, 1991). Thirteen of these accessions were harvested in January, 1994 after 4 seasons growth from 1990 through 1993 (Table 2) without a killing freeze. The annual dry matter woody stem yield averaged 19.7 Mg ha^{-1} yr^{-1} when yields were adjusted to 1/2 of increased plot space resulting from competition with adjacent single rows over the 15 years since planting. This was based on hypothesis that the adjacent living leucaena plot was equally competitive as the plot harvested to the increased space.

CONCLUSIONS
Leucaena can be grown as an annual, woody biomass crop or without freezes 2 or more years as a short rotation woody crop. Adapted perennial tall grasses can be grown in lower South. Winter temperatures set the northern limits to these crops and it is important to plant cultivars adapted to the area in which the crop is to be grown.

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Table 1
Average annual biomass yield of elephantgrass (eg), energycane (ec), sugarcane (sc), sweet sorghum (ss) and forage sorghum (fs) at five locations in Southeastern United States over three growing seasons, 1987-89.

	Oven dry biomass				
	Florida				Alabama
Crops	Ona	Gaines-ville	Quincy	Jay	Auburn
Mg ha^{-1} yr^{-1}					
N-51 eg	46.7	39.7	33.8	32.1	24.0
PI 300086 eg	41.6	28.6	24.1	24.0	18.6
L79-1002 ec	23.3	32.2	30.1	33.9	24.2
CP72-1210 sc	19.4	10.4	19.2	8.2	6.0
M81E ss†	23.0‡	11.3	10.0	18.5	7.8
Pioneer 931 fs†	23.8‡	11.0	11.7	20.9	5.3

† Two harvests per season at most locations and years.
‡ Average over only two seasons; serious Pythium and nematode problems occurred.
Table derived from Prine et al. (1991).

Table 2
Dry matter annual and 4-year growth yields of pole wood and tops over 12 and 13 selected leucaena accessions planted in 1979 at Gainesville, FL.

	Dry matter yield				
Dry matter yields	Growth period	Tops	Pole wood	Total	Avg. annual yield
			Mg ha^{-1}		
Avg. annual yield over 12 accessions in original 6 M^2 plots†	1982	—	—	29.3	29.3
	1983	—	—	24.7	24.7
	1986	—	—	40.2	40.2
	1987	—	—	33.4	33.4
	4 year total	—	—	127.6	31.4
Avg. 4 year growth of 13 accessions ‡ adjusted for 1/2 of increased plot space after 15 years	1990 through 1993	23.9	55.0	78.9	19.7

†Taken from Cunilio and Prine, 1994 and 1995.
‡ The average plant DBH over the thirteen accessions after 4 years growth was 7.3 cm, number of stems per 6 m^2 plot was 21 and average stem height was 8.3 meters.

Figure 1
The Humid Lower South, U.S.A.