A COMPARISON OF SOME FAST GROWING SPECIES SUITABLE FOR WOODLOTS IN THE WET TROPICS

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ABSTRACT - An interest in ways of reducing the area of and cycle time for shifting cultivation has led to a brief look at some fast growing forestry species for fuel.

The following three species obtained from our forestry department, *Eucalyptus deglupta* (Mirtaceae), *Cedrelinga catenaeformis* (Leguminosae) and *Jacaranda copaia* (Bignoniaceae), were compared on a poor ultisol with *Inga edulis* (Leguminosae) used locally as a quick growing cocoa shade. Trees were harvested at two years of age in the field when the biggest trees had a stem weight that could still allow a man to bring it home (75 kg).

Mean dry stem wood yields per ha were 45.8 t for *E. deglupta*, 14.8 t for *I. edulis*, 8.9 t for *J. copaia* and 4.7 t for *C. catenaeformis*. There was no response to NPK in any species. *I. edulis* nodulated very well and N fixers were detected in the washed roots of *E. deglupta*. Only *I. edulis* regrew well because leaf cutting ants eliminated the succulent regrowth of *E. deglupta* and *J. copaia* inspite of several attempts of control. The low yields of the first crop of the latter were partly due to a similar attack by ants and many *C. catenaeformis*, and a few *E. deglupta* suffered fungal attacks. A few *Eucalyptus* were also slightly defoliated by bagworms (Psychidae). In a subsequent experiment, 99% of *I. edulis* seedlings survived a very strong drought compared to 78% of *E. deglupta* and 46% of an acid tolerant cultivar of *Leucaena leucocephala*. 70% of *I. edulis* seedlings from seed sown directly in the field also survived.

Although *E. deglupta* is the obvious species of choice for large well managed plantations on better soils, *I. edulis* has many advantages as a woodlot species suitable for the shifting cultivator in this region. These include the ease of direct planting of seeds in the field, the ability to coppice, a tolerance to drought and leaf cutting ants, the fixation of N_2 and the provision of wood of stove size, of good shade and of edible fruit. Yields could be improved rapidly by selection as some trees weighed twice the mean. Better form, less crown and higher density may be found amongst the 100 or more *Ingas* of Latin America. These now deserve more attention along with the problem of exhausting the nutrients in poor soils with quick growing species.

Index terms: poor soils, legume trees, rain forest.

UMA COMPARAÇÃO DE ALGUMAS ESPÉCIES DE CRESCIMENTO RÁPIDO ADEQUADAS PARA PRODUÇÃO DE LENHAS EM TRÓPICOS ÚMIDOS

RESUMO - O interesse em reduzir a área e o tempo do ciclo da agricultura itinerante motivou a análise de algumas espécies florestais de crescimento rápido para produção de energia.

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As três espécies: *Eucalyptus deglupta* (Mirtaceae), *Cedrelinga catenaeformis* (Leguminosae) e *Jacaranda copaia* (Bignoniaceae) foram comparadas com *Inga edulis* (Leguminosae, usada para sombreamento de cacau) em um solo Podzólico pobre. As árvores foram colhidas com dois anos de idade, quando a maior árvore apresentava tronco com 75 kg, possível de ser carregado para casa por um único homem.

A média do peso seco da madeira do tronco por ha foi 45,8 t para *E. deglupta*, 14,8 t para *I. edulis*, 8,9 t para *J. copaia* e 4,7 t para *C. catenaeformis*. Nenhuma espécie respondeu a adubação de NPK. *I. edulis* nodulou muito bem e fixadores de nitrogênio foram detectados em raízes lavadas de *E. deglupta*. *I. edulis* foi a única espécie que regenerou bem após o ataque de formigas cortadeiras, as quais eliminaram os brotos de *E. deglupta* e *J. copaia*, apesar de várias tentativas de controle. A baixa produtividade da primeira colheita de *J. copaia* foi também, parcialmente, devido ao ataque de formigas e muitas plantas de *C. catenaeformis*; algumas de *E. deglupta* sofreram ataques de fungos. Algumas árvores de *Eucalyptus* foram também, parcialmente, desfolhadas por lagartas (Psychidae).

Em um segundo experimento, 99% das mudas de *I. edulis* sobreviveram a uma seca rigorosa, comparados com 78% de *E. deglupta* e 46% de uma cultivar de *Leucaena leucocephala* tolerante à acidez. Setenta por cento das mudas de sementes de *I. edulis* plantadas diretamente no campo sobreviveram.

Apesar de *E. deglupta* ser obviamente a espécie a ser escolhida para grandes plantações, bem manejadas em solos melhores, *I. edulis* apresenta muitas vantagens como espécie para pequenas plantações, adequada para agricultura itinerante na região. Esta espécie apresenta facilidade de plantio direto de sementes no campo, habilidade de rebrotar, tolerância à seca e formigas cortadeiras, capacidade de nodular e fixar N_2 e produzir madeira com tamanho adequado para fogão, e ainda produzir boa sombra e frutos comestíveis. As produções podem ser melhoradas rapidamente por seleção de algumas árvores que pesaram o dobro da média. Melhorar a forma diminuindo a coroa e maior densidade da madeira podem ser encontradas entre as 100 ou mais Ingas da América Latina. Estas considerações e o problema de exaustão dos nutrientes em solos pobres com espécies de crescimento rápido são problemas que merecem mais atenção.

Termos para indexação: solos pobres, leguminosas arbóreas, floresta trópico-úmida.

INTRODUCTION

The importance of wood as an ancient fuel is well known but it is not always appreciated that it still remains one of the principle fuels in most of the third world. Increasing populations have eliminated or are threatening many areas of tropical forest because of their need for fuel wood and for new land for shifting cultivation. Whilst the threat to the Amazon forest from these causes, has been small to date, rapid colonization and vast fuel needs for mineral exploitation will now put increasing pressure on the forest in some areas. To avoid complacency, it is worth remembering that the charcoal that supplies 40% of Brazil's steel industries needs comes from as far as 1,000 km from Belo Horizonte. The planting of woodlots for fuel is an attractive partial solution and is receiving considerable attention (Forestry . . . 1978, Eckholm 1975 and King 1980). Not only is wood a renewable energy source but it outyields all other biomass sources of fuel, does not necessary compete with food crops as it can be grown on marginal land

and it is easy to store and readily used (Dobereiner et al. 1981). Apart from their use as fuel it may also be possible to plant certain fast growing species to reduce the fallow time in shifting cultivation and thus allow faster rotations. This would lead to the need for a smaller cropping area which would relieve pressure on the natural forest.

Many species have been recommended for different regions (Burley 1980 and National Academy of Sciences 1980). In this paper a fast growing exotic, *Eucalyptus deglupta* (Mirtaceae) from New Guinea is compared with the most promising local non-legume, *Jacaranda copaia* (Bignoniaceae), and legume, *Cedrelinga catenaeformis* (Leguminosae), selectec by our Forestry Department (P.N. Fernandes) and a local cocoa shade tree, *Inga edulis* (Leguminosae).

EXPERIMENTAL

Expt. 1. Seedlings, 50 cm tall and about three months old, were planted in small plots in a 2 m triangular spacing after *Panicum maximum* on a well used ultisol near Manaus. There were three replicates and plots were split to give fertilizer to one half. 100 g of P_2O_5 as triple superphosphate were placed in and around the planting hole and 50 g of N as urea and 50 g K_2O as KCl were broadcast in five split dressings during each year. Trees were harvested after two years in the field when the biggest tree had a stem weight that could still allow a man to drag it home (75 kg). Trees were cut at a height of 25 cm and the stem wood taken to a minimum of 2.5 cm diameter. The latter and the foliage were weighed and sampled for drying and density measurements. The regrowth from *I. edulis* was harvested one year later.

Expt. 2. 50 to 100 seedlings of four Inga introductions and the seed of another were planted out in single plots in comparison with *E. deglupta* and an acid tolerant *Leucaena leucocephala* (selected by E.M. Hutton at CIAT) after two crops of cassava. Height and survival rates after one year are presented.

Complete soil analyses were made by the Tropical Soils Analysis Unit of the Land Resources Development Unit (Reading, U.K.), on the top 20 cm at the start of each experiment.

RESULTS AND DISCUSSION

Table 1 shows how very poor two fairly typical Amazon soils are, not only in exchangeable and available but also in total nutrients. Inspite of this, most of the trees grew well (Table 2) unless attacked by insects or disease. *J. copaia* was seriously attacked by *Atta* spp., and *C. catenaeformis* by an unknown systemic fungus. A few *E. deglupta* trees were attacked by bagworms and *Cylindrocladium* sp. Leaf cutting ants (*Atta* spp.) were partially controlled with Mirex and Methyl Bromide. Bagworms (Psychidae) were sucessfully controlled with *Bacillus thuringiensis.* These attacks, site specificity and variability are reflected in the yields of the best trees which are several times those of the average for most species. *E. deglupta* is vastly superior to the other three species in yield but both its regrowth and that of *J. copaia* were eliminated by a combination of leaf cutting ants and drought. *I. edulis* was not affected by either and coppiced very well.

Table 3 shows that the wood of *I. edulis* is considerably drier than the other two species and this helped it to outyield *J. copaia* and *C. catenaeformis.* No effect of the heavy NPK applications was seen

TABLE 1. Soil analysis at start of experiments.

	Particle size μm 2	2-50	50-2000	% H_2O	Bulk density	pH 1:5 H_2O	% N	% C
Exp. 1	41	12	47	1.3	1.01	5.0	0.12	1.28
Exp. 2	21	6	73	0.9	1.09	4.9	0.09	0.88

	Exchangeable cations Na	K	Mg	Ca	T.E.B.	C.E.C.	% Base Sat.	Available P ppm Bray	Olsen
Exp. 1	< 0.05	< 0.05	0.2	1.4	1.6	3.9	41	6	4
Exp. 2	< 0.05	< 0.05	0.1	0.1	0.2	2.5	8	2	2

	Perchloric acid digestion ppm P	K	Mg	Cu	Mn	Zn	Fe %	Total S ppm	Hot water sol. B ppm
Exp. 1	140	100	50	< 5	90	20	3.25	110	1.51
Exp. 2	60	50	50	< 5	50	< 5	0.96	50	0.70

T.E.B. = Total exchangeable bases
C.E.C. = Cation exchange capacity

in any species inspite of the poverty of the soils. No visible signs of deficiency were noted, except for a suspicion that the *Cylindrocladium* attack may have been due to a lack of Boron. The very high dry matter and volume yields of the *E. deglupta* are largely due to the excellent growth produced by the high radiation, temperature and rainfall found in the Amazon. Side light may have helped in the small plots used although no border effects were detected. All the species have low and similar densities. *J. copaia* is slightly lighter in weight and colour than the others. It also has an excellent form with a high stem to crown ratio (Table 4) and it self prunes. *I. edulis* has a poor ratio and form, usually branching below a metre which leads to a heavy crown and a high biomass yield. Some of the 100 or more other Ingas have a better ratio and seem worth studying (e.g. *I. cinnamomea*). However the poor form, which may explain the lack of previous interest of traditional foresters, is not so important in a fuelwood species as in one used for timber. Wood of the right size for a stove without spliting may in fact be a more important characteristic and more common in heavily branched species.

Both legumes nodulated well, especially the *I. edulis* and N_2 fixing bacteria were isolated from washed *E. deglupta* roots but not identified (N. Asakawa unpubl. data).

The results of the second experiment (Table 5) show how superior the *Inga* spp. were on a worse site after cassava in a very dry year. Both leaf cutting ants and the drought caused large losses and poor growth in the more vulnerable *E. deglupta* and *L. leucocephala*. Direct sowing of *I. edulis* seed in the field gave good results; however small *E. deglupta* seedlings failed miserable.

TABLE 2. Mean height, diameter, fresh stemwood weight and regrowth.

Species	Mean tree height (m)	Mean diameter (D.B.H) cm	Mean fresh stemwood wt. kg/tree	Fresh stemwood wt. best tree kg	% trees that regrew	% trees left after 1 year
E. deglupta	11.2	10.2	44.3	75.5	93	0
I. edulis	6.0	7.5	9.7	25.3	100	100
J. copaia	4.4	6.4	8.9	52.5	80	0
C. catenaeformis	4.2	4.2	4.2	13.5	83	40
L.S.D.			16.8			
I. edulis regrowth	5.0	5.2	6.4	17.2	100	100

D.B.H = Diameter at breast height.

TABLE 3. Moisture content, dry yields, density and volume of the stemwood.

Species	Stemwood mean % H_2O	Stemwood dry weight kg/tree			Yields of dry stemwood t/ha	Density = dry wt. / Wet vol.	Volume m^3/ha 2 yrs.
		+ fertilizer	- fertilizer	Mean			
E. deglupta	36.0	13.0	18.8	15.9	45.8	0.37	124
I. edulis	52.1	5.4	4.6	5.0	14.8	0.34	44
J. copaia	35.0	3.6	2.6	3.1	8.9	0.31	29
C. catenaeformis	38.7	2.2	1.0	1.6	4.9	0.37	13
L.S.D.				6.2			
I. edulis regrowth	49.5	-	-	3.2	9.2	0.34	27

TABLE 4. Percentage of stemwood and biomass yield.

Species	% Dry stemwood / Dry tree	Dry biomass yields (t/ha)
E. deglupta	67.8	67.6
I. edulis	52.2	28.3
J. copaia	74.3	12.0
C. catenaeformis	55.2	8.5
L.S.D.	12.4	16.6
I. edulis regrowth	39.8	24.0

Using the *I. edulis* regrowth data (27 m^3/ha/yr), a man could produce 1.3 m^3/year from trees planted at 2 m round a 30 x 40 m plot. This is close to the 1.27 m^3/yr. per caput consumption estimated for a Thailand village (Debacker & Openshaw 1972/3).

A major fear with fast growing species on poor soils is that they will rapidly exhaust the nutrients. Although no data is yet available for the species examined here, Table 6 shows the contents of nutrients in an equivalent weight of *E. grandis* and *Pinus caribea* and the rates at which they might exhaust the exchangeable and total resources in experiment 1. Obviously roots can obtain nutrients from greater depths than 10 cm and use part of the total nutrients measured as unavailable by methods designed to correlate with the growth of annual agricultural crops. These variables are unknown but clearly P, K and Mg at least can be seriously exhausted in a short time. Rain inputs far from the sea are also negligible. There is thus a good case for not cropping at too high a rate in such soils, for selecting soils with larger nutrient reserves and for selecting trees with especially low nutrient contents.

TABLE 5. Height and survival at 17 months after a long drought on a poor site.

Species	Introduction	Age from germination months	Planting height	Height of survivors at 17 months in field m	% survival
Inga edulis	canela 166	20	25	3.5	100
	canela 155	22	40	3.7	100
I. macrophylla	chata 160	21	30	3.2	100
I. edulis	comum 161	21	30	3.0	96
	comum 170	17	0	2.4	70
E. deglupta	Fernandes 1980	18	10	-	7
	Fernandes 1980	19	20	0.7	50
	Fernandes 1980	20	30	2.8	71
Leucaena leucocephala	Hutton 6	20	30	1.4	46

TABLE 6. Nutrient content of wood (45.8 t dry) and soil and theoretical exhaustion rates for expt. 1.

	kg/ha					References
	N	P	K	Ca	Mg	
Eucalyptus grandis Stemwood	85	8.5	22.9	-	-	Balloni, E.A. (1979)
Eucalyptus grandis whole tree	215	22.9	78.9	-	-	Balloni, E.A. (1979)
Pinus caribaea Stemwood	82.4	18.6	29.4	18.6	15.7	Chijioke, E.O. (1980)
Pinus caribaea whole tree	193.2	32.4	45.1	76.5	24.5	Chijioke, E.O. (1980)
Soil content exchangeable or available kg/10 cm	-	9.0	30	420	36.5	
Soil content total kg/10 cm	1800	210	150	-	75	
Rain imputs kg/ha/yr.	1.2	0.3	2.3	2.3	-	Franken W. unpubl. date
Cycles to exhaust exchangeable nutrients to 10 cm*	-	1.1	1.3	22.6	2.3	
Cycles to exhaust total nutrient to 10 cm*	21.2	24.7	6.6	-	4.8	

* NPK using *E. grandis* and CaMg using *P. caribaea* data.

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