PELTOPHORUM PTEROCARPA (DC.) BACK (CAESALPINIACEAE), A TREE WITH A ROOT DISTRIBUTION SUITABLE FOR ALLEY CROPPING ON ACID SOILS IN THE HUMID TROPICS

M. VAN NOORDWIJK (1), KURNIATUN HAIRIAH (2), SYEKHFANI MS (2) and E.N. FLACH (1)
1. Institute for Soil Fertility, P.O. Box 30003, Haren (Gr.) (the Netherlands)
2. Universitas Brawijaya, Fakultas Pertanian, Malang (Indonesia)

ABSTRACT

The root distribution of *Peltophorum* was investigated after two years of pruning (twice a year) at three different heights (25, 50 and 75 cm). Pruning height had a marked effect on the number of branch roots originating from the stem base. Possibilities are discussed for manipulating the tree so as to form a root distribution pattern desirable for alley cropping.

INTRODUCTION

Alley cropping is a cropping system with food crops planted between regularly pruned trees; it is an alternative to shifting cultivation and seems to be a promising way to maintain soil organic matter levels and food production potential under tropical conditions (Kang et al., 1984). For this system to function properly, tree species are needed which tolerate regular pruning, have a good biomass production and a deep root system with few roots in the top layer in the zone occupied by the food crops (Fig. 1). If possible, N_2-fixing trees such as *Leucaena leucocephala* are used. A deep root system spreading as a "safety net" under the crops may, by intercepting leached nutrients, improve the nutrient use efficiency of the cropping system. On acid soils, where *L. leucocephala* does not perform well, no trees are known that meet all these requirements. Hutton & De Sousa (1987) reported that *L. leucocephala* (cv Cunningham) performed poorly on an acid oxisol in Brazil (pH 4.5-4.7) and that even after lime applications (tested at rates up to 2 t/ha) large numbers of dead root tips indicated Al-toxicity. More acid-tolerant *Leucaena* hybrids are being developed. Koffa and Mori (1987) tested the effects of pH and Al concentrations in a nutrient solution experiment with four strains of *Leucaena leucocephala*. The strains differed in Al-tolerance; the strain with the highest growth rate at low Al-concentrations was the least tolerant. Other trees than Al-tolerant *Leucaena* are thus required, especially because diversity in tree species is needed. On the site of an EC-sponsored project on "Nitrogen management in cassava-based cropping systems in the humid tropics" in S. Sumatera, Indonesia (Setiyono et al., 1989), we tested local trees for their suitability for alley cropping.

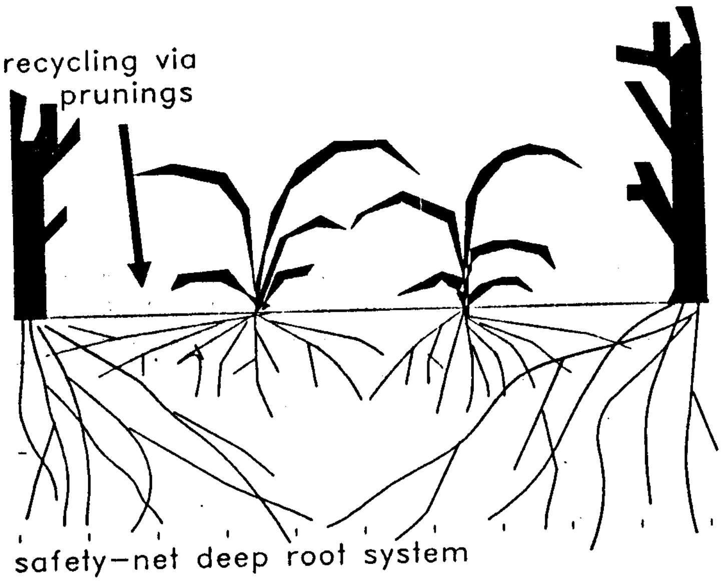

Fig. 1. Schematic presentation of the alley cropping system with tree roots underneath shallow crop roots.

Initial observations on root development of seedlings of three locally abundant trees showed that *Peltophorum* developed by far the deepest root system. The tree establishes itself rapidly in secondary forest and in weed-infested fields ("alang-alang" or *Imperata cylindrica*) from seed and stays green in the dry season. In the older Indonesian forestry literature *Peltophorum* is mentioned as suitable for soil improvement in *Tectona* plantations. It is reported to grow well in dense *Imperata* fields and to outshade *Imperata* in the long run. Webb et al. (1984) summarized information on *Peltophorum pterocarpum* (DC) Heyne (synonyms: *P. ferrugineum* (Decne.) Benth., *P. inerme* (Roxb.) Naves). Its altitudinal range is 0-1000 m and it mainly grows in the climatic zone having a mean annual rainfall of 1000-1800 mm, with a dry season of 4-6 months. It prefers well drained soils and tolerates poor soils. The tree is known to coppice well and is considered to be fast growing. The tree is used as a shade tree in coffee and cacao plantations and can help in the reclamation of Imperata grasslands. *Peltophorum* bark used to have some commercial value because of its tannin content.

As the initial information seemed promising a small experiment was conducted to test the pruning tolerance and coppicing behaviour of *Peltophorum* and to study root development in a later stage.

1. METHODS

Thirty spontaneous seedlings of *Peltophorum* were selected in May 1986, growing on land cleared of forest and Bburned in October 1985. Seedlings of similar size were selected (about 2 m high, stem diameter about 2 cm at 10 cm height), cleared of surrounding vegetation, labelled and randomly assigned to three treatment groups. The trees, at this stage unbranched, were pruned at 25, 50 and 75 cm above the soil surface (t1). In February 1987 (t2), trees were cleared of surrounding vegetation again and pruned again at the original height. In June (t3) and November (t4) 1987 this was repeated. In November root distribution was studied by excavating segments of soil around several trees and mapping roots in a vertical plane close to the stem; for a larger number of trees the soil around the stem in the top 10 cm was removed and horizontal branch roots were observed.

2. RESULTS

2.1 Aboveground growth

Until the third pruning all trees survived the pruning treatments; at the fourth observation three trees (out of thirty) had died. At the second pruning only the number of branches was significantly influenced by pruning height (Table 1). At the fourth pruning the length of the longest branch, the number of branches and total freshweight of prunings were significantly higher for pruning at a higher level. Stem diameter showed no significant differences between treatments. At t4 a larger number of branches was present than at t2. Figure 2 shows the branching pattern of two trees at t4: after the initial pruning of the main stem, one or two new branches, originating 10-15 cm below the pruning level, took over most of the growth. After pruning these stems at t2, new branches emerged to form a dense "head" in the top 15 cm, as well as lower down the stem, giving the plant a shrub-like appearance. Apical dominance gradually decreased, as can be seen from the larger number of smaller branches.

Biomass production was almost twice as high for the 75 cm pruning height as for the 50 and 25 cm pruning height (Table 1). Nitrogen content of leaves is about 3.5% and of stems about 1.4%. A tree population of 5 000 trees per ha (4 m between alleys, trees 0.5 m apart in the alley) producing 2 kg fresh weight per tree twice a year would give an input of 20 t of biomass per ha per year (roughly 1/3 branches and 2/3 leaves). Assuming that the prunings contain 50% dry matter and that this dry matter contains 2.8% N this amount corresponds to 280 kg N per ha per year.

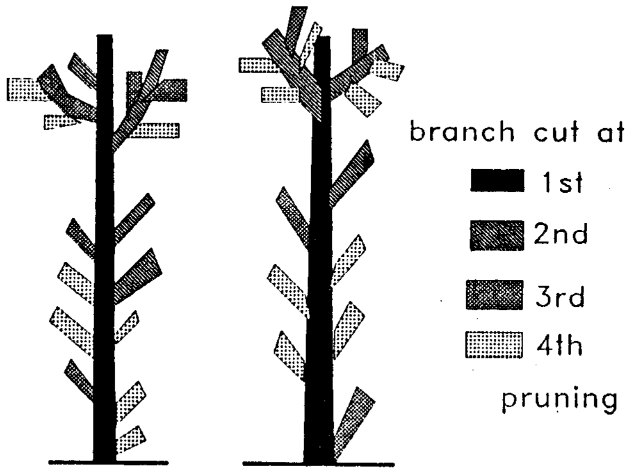

Fig. 2. Branching pattern of two trees pruned at 75 cm above ground level.

TABLE 1

Aboveground growth of *Peltophorum* under three pruning regimes at two observation dates (t2 and t4). Average values and results of ANOVA are given (NS = no significant difference, * = significant difference (P < 0.95), ** = idem (P < 0.99), s.e.d. = standard error of differences of means).

Height of pruning (m)		0.25	0.50	0.75		s.e.d
Number of replications	t2	10	10	10		
	t4	9	10	8		
Length of longest branch (m)	t2	1.59	1.29	1.48	NS	
	t4	0.77	0.80	1.09	*	0.11
Number of branches	t2	1.9	2.8	3.2	*	0.5
	t4	6.3	6.6	9.6	*	1.2
Fresh weight of prunings/plant (kg)	t2	0.63	0.69	1.28	NS	
	t4	0.86	0.98	2.11	**	0.38
Dry/fresh weight	t4	0.52	0.53	0.50	NS	
Stem diameter (mm)						
125 mm above ground	t4	26.4	24.9	34.1	NS	
125 mm below head	t4	26.4	21.9	27.8	NS	

Root distribution

When the trees were 6 months old a deep taproot and few horizontal branch roots were found. At an age of two years the taproot had penetrated to at least 1 m depth, into the zone with abundant iron concretions (Figure 3). Horizontal branch roots were present in the topsoil, which penetrated the subsoil as "sinker" roots at some distance from the stem; some could be traced to 1 m depth. In the subsoil branch roots from the taproot followed an approximately horizontal course; when the taproot itself changed direction, branch roots continued vertically downward.

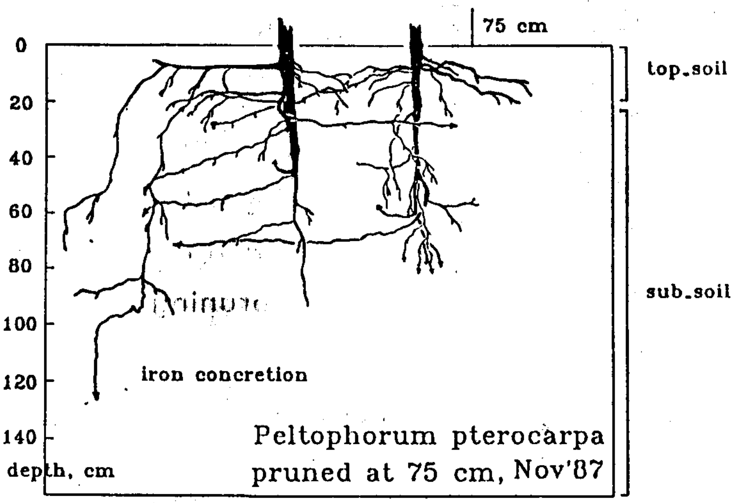

Fig. 3. Root distribution mapped in a 30° segment on opposite sides of the stems of two 2-year old trees pruned at a height of 75 cm.

The pruning treatments influenced the branching pattern of roots, as was further investigated by excavating the top 10 cm around a large number of trees. Top views of the root systems are shown in Figure 4, quantitative data are presented in Table 2. A lower pruning height resulted in more branch roots in the top 10 cm, but with a small diamater. Pruning at 75 cm height resulted in some thick branch roots and a smaller number of fine ones. Two naturally grown trees outside the experiment but of about the same age (height 5 m, stem diameter 4 to 8 cm) had fewer but thicker roots than the trees pruned at 75 cm.

No nodules were found on the roots. Absence of nodulation is common in the *Caesalpinioideae* subfamily of the *Legumionosae*. The closely related *Delonix* (flamboyant) and *Cassia* usually have no nodulation either, although exceptions are known to exist (Lim and Burton, 1982).

DISCUSSION

The data discussed here show that *Peltophorum* is a tree which at least partly meets the requirements for alley cropping: it is tolerant to pruning (at least twice a year) and readily forms new branches from various positions on the stem; it has a reasonable biomass production of prunings and the root distribution approximates the ideal pattern for an alley-tree more closely than other trees observed in acid soils so far (Hairiah & Van Noorwijk, 1986) in SE Nigeria.

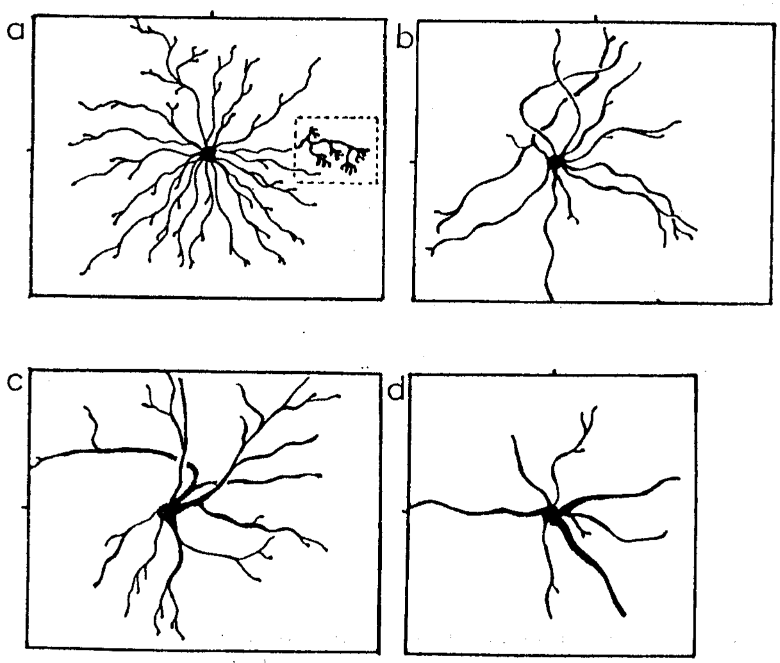

Fig. 4. Top view of root branching pattern in the top 10 cm of the soil for a pruning height of a) 25 cm, b) 50 cm, c) 75 cm and for d) non-pruned roots.

TABLE 2

Number of branch roots (average ± standard deviation) originating from stem base and taproot in the top 10 cm of soil, classified according to their diameter; measurements of two trees outside the experiment, of comparable age but not pruned, are included.

Pruning height	Diameter class (mm)			Total number
	< 5	5-20	>20	
25 cm (n = 5)	25.4 ± 12	1.2 ± 1.3	0	26.6 ± 11.7
50 cm (n = 4)	13.5 ± 6.0	4.0 ± 2.2	0	17.5 ± 7.9
75 cm (n = 4)	13.3 ± 6.9	3.5 ± 1.3	1.8 ± 1.5	18.5 ± 7.1
Not pruned (n = 2)	9.5	0	3	12.5

In literature pruning height has so far been mainly discussed for its effects on biomass production and/or shading of the crop. Dutt & Jamwal (1987) compared firewood production of *Leucaena* coppiced at five different heights

(0-100 cm above ground level) in the first three years. A pruning height of 50 cm was recommended to maximize firewood production. Coppicing at a 25 cm level gave an equal number of branches, but a lower volume. In our research another important effect of the pruning height was recorded: it appears to be possible to influence the root distribution pattern by pruning. More but finer branch roots in the topsoil are formed when the trees are pruned at a low level. The apparent loss of apical dominance in the root system under a pruning regime coincides with the loss of apical dominance in aboveground growth, leading to a shrub-like form. Increasing the pruning frequency may have an effect similar to that of reducing pruning height. To obtain a suitable rooting pattern in alley cropping it may be necessary to delay the first pruning at least till the stage in which the trees studied here were first pruned (stem height 2 m) to allow a good taproot development, and to subsequently prune at a height of 75 cm. Later, pruning frequency may be increased to avoid thick horizontal branch roots developing into the zone intended for crops in the alley cropping system. Further observations on rooting pattern under such a pruning regime are required.

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