Root turnover of tropical trees and crops in Sumatra, Indonesia

Kurniatun Hairiah*, Meine van Noordwijk, Subekti Rahayu**, Sandy E. Williams** and Ni'matul Khasanah****

* Brawijaya University, Malang, Indonesia

**World Agroforestry Centre (ICRAF) SE Asia, Bogor, Indonesia

Introduction

Root turnover is important in the functioning of plants and agro-ecosystems for a number of reasons:

- Belowground allocation of C (energy) may be around one-third of the C (energy) in the plant as a whole
- C (energy) provided by roots is a major source of C for the food web of soil biota
- As roots are lost to 'rhizovory' (consumption), plants needs to invest continuously in roots to maintain root length density
- Through various channels, belowground plant C allocation contributes to soil organic matter (C_{org})

Research questions

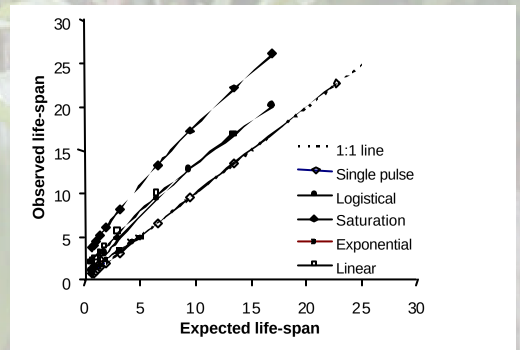
How long do (fine) roots live?

Material and Methods

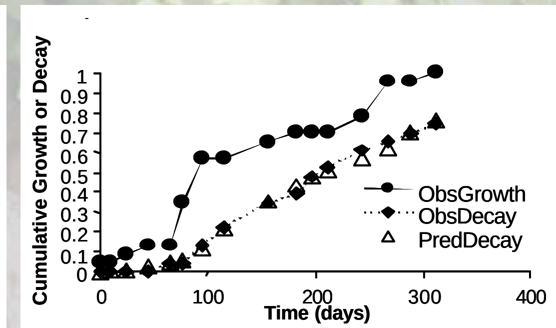
- Measurement of root mortality in the field using minirhizotrons was carried out in long-term experiments in Lampung and Jambi (Indonesia).
- Images from roots growing along an observation surface were obtained with a telephoto lens with a camera at the soil surface.
- Inflatable minirhizotrons were inserted into soil close to annual crops (rice, maize, groundnuts, velvet beans (*Mucuna pruriens* var. *utilis*) and *Imperata cylindrica*) and trees i.e. *Peltophorum dasyrrachis* and *Gliricidia sepium*, to an effective depth of 60 cm. Similar observations were made in young rubber in Jambi (Indonesia).
- Roots were observed monthly and a total of 18 sets of photographs (representing depths of 0-10, 10-20, 20-30, 30-40 and 40-60 cm), from the period December 1995 through March 1996.
- The images were assessed as a time series and all changes (**+** or **-**) in root intersections with a standard grid of lines were recorded. From these data the cumulative pattern of root growth was derived and root disappearance was expressed as fraction of cumulative root growth, using a new algorithm that is less sensitive to the temporal pattern of root growth than the one formerly used.

Results

Root growth of Gliricidia at different time of observations



The method previously used for analyzing minirhizotron data (van Noordwijk, 1993) can lead to overestimate of lifespan of roots, depending on pattern of root growth



In a new method we find the **daily survival rate** (and hence lifespan) that best fits observed decay, given the observed growth

Table 1. Root dynamics as observed using minirhizotrons at the Biological Management of Soil Fertility (BMSF) site in N. Lampung, Sumatra, Indonesia, in cropping system trials during the period 1996–1999. Data from 6 minirhizotrons per species, with daily survival rate and median lifespan (age expected to be reached by 50% of each cohort of roots) evaluated for individual replicates.

Plant species	Remarks	Daily survival probability[2]	Median lifespan (days)	Daily turnover(%)
Gliricidia sepium	Regularly pruned in alley cropping	0.9904[a]	116.8[a]	0.96
Peltophorum dasyrrachis	Regularly pruned in alley cropping	0.9877[a]	121.1[a]	1.23
Flemingia congesta	Regularly pruned in alley cropping	0.9916[a]	96.1[a,b]	0.84
Zea mays (maize)[1]	In alleys or as mono-crop	0.9435[c]	25.2[c]	5.65
Arachis hypogaea (groundnut)	In alleys or as mono-crop	0.9547[b,c]	20.4[c]	4.53
Mucuna pruriens* var. *utilis	As cover crop in rotational system	0.9534[b,c]	17.7[c]	4.66
Oryza sativa (upland rice)	In alleys or as mono-crop	0.9614[b,c]	33.8[c]	3.86
Imperata cylindrica	As weed on fallow land	0.9844[a,b]	55.2[b,c]	1.56
Grand mean		0.9679	59.8	
Probability		*P*=0.005	*P*<0.001	
Standard error of difference between means		0.0188	30.1	

Table 2. Root dynamics as observed using minirhizotrons in a rubber (*Hevea brasiliensis*) agroforestry experiment in Rantaupandan, Jambi, Indonesia, during 1997 and 1998, with weeding intensity as the main experimental factor and the distance from the tree as the sampling position. Data from 4 minirhizotrons per sampling position and weeding intensity combination, with daily survival rate and median lifespan evaluated for individual replicates.

Experimental factor/sampling position	Daily survival probability	Median lifespan (days)	Daily turnover (%)
'High' weeding intensity	0.9960	241	0.40
'Low' weeding intensity	0.9955	344	0.45
Within tree row (0.25 m from tree)	0.9953	328	0.47
Between tree rows (1.5 m from tree)	0.9962	257	0.38
Grand mean	0.9958	293	
Probability	NS	NS	
Standard error of difference between means	0.00248	95.2	

Conclusions

The shortest median fine root lifespans and highest daily turnover rates (1–daily survival probability) were found to occur in the leguminous cover crop *Mucuna pruriens*, followed by groundnut and maize.

- The median longevities were between 18 and 25 days, whilst all three annuals had a turnover rate of about 5% day^{-1}.
- Three species of trees studied i.e. *Peltophorum dasyrrachis*, *Gliricidia sepium* and *Flemingia congesta* had median fine root longevities of about 100 days and turnover rates of about 1% day^{-1}.
- The longevity and turnover rate of the perennial grass *Imperata cylindrica* fell between those of the annual crops and trees. The rubber data for Jambi showed a daily turnover of around 0.5% and a median lifespan of 290 days.