Above- And Below-Ground Nitrogen Contribution By Legume Tree To An Associated Corn Crop

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Introduction

In agroforestry cropping systems knowledge on nutrient contribution of above-ground biomass inputs to crop production are numerous (Sanchez et al., 1989), but little is known on the role of the below-ground root biomass, though it has been stated that fine root decomposition can be an important source of nutrients due to it being within the crop rooting zone (Giller et al., 1991; Lehmann et al., 1995 and 1998). Studies on nutrient cycling from decomposing roots in integrated cropping systems has been ignored due to cumbersome and difficult methodologies involved. Current methods of quantifying root biomass by excavation are laborious and time consuming and it is also destructive to the entire plant and the soil environment.

Materials and Methods

Twelve 1 m^3 aluminum containers were filled with a Bungor series soil (Typic Paleudult) to a height of 0.90 m. Six containers were planted with one *P. falcataria* tree at the center each. The following were the initial soil properties: pH (1M KCl) of 6.05, pH, organic C (Walkley–Black, 1934) of 6.79 g kg^{-1}, Total N of 0.73 g kg^{-1}, P (Olsen et al. 1954) of 17.68 g kg^{-1} and mineral N (NH_4-N + NO_3-N) of 102.73 mg Kg^{-1}. The soil texture (USDA) was clay with 68.57% clay, 22.60% sand and 8.75% silt. Nine months after planting, four trees of uniform size were randomly selected and injected with ^{15}N using the method Horwath et al. (1992).

Four weeks after ^{15}N injection, above-ground biomass of all trees were harvested and their yield determined. Soil samples were also taken from all containers for pH and mineral N analysis. The following treatments were randomly assigned to appropriate containers in a Complete Randomized Design (CRD) with two replications: (1) ^{15}N labeled leaves only, (2) ^{15}N labeled roots only, (3) ^{15}N labeled leaves + Unlabeled roots (Mixture 1), (4) ^{15}N labeled roots + Unlabeled leaves (Mixture 2), (5) Unlabeled leaves + ^{15}N labeled soil, and (6) Control (^{15}N labeled soil only). Tree leaves were surface applied in the respective plots in two equal splits of one kg fresh weight per container at each application at 4 and 8 weeks after planting of corn. One tree which was not part of the treatments was destructively sampled to determine above-to below-ground biomass ratio. Corn plants were respectively harvested from each plot at physiological maturity age (89 days after planting). Corn grain, stover and husk biomass yields were determined on oven dry weight basis. Finely ground corn sub samples, and *P. falcataria* tree components (enriched with ^{15}N by injection and used as source of N) were analyzed for total N content and ^{15}N enrichment. Percentage of N derived from *P. falcataria* residues by corn at physiological maturity stage (%Ndfr) and the residue N use efficiency (%rNE) was calculated by the following ratios proposed by Zapata, (1990). The data were analyzed using SAS software (SAS, 1988). Duncan Multiple Range Test (DMRT) was used to compare treatment means at 5% significant level.

Results and Discussion

The highest percentage of N contributed to corn was from the *P. falcataria* roots alone (averaging 57%) followed by the *P. falcataria* roots when they were combined with leaves (40%). The N contribution of *P. falcataria* leaves whether in mixture (10%) or when used alone (14%) was relatively low and not significantly different. The ^{15}N-direct injection method and the ^{15}N-indirect or dilution method compare very well as potential means or tools for determining N cycling from applied leaf residues . The injection of tracer N provides a relatively easy means to transfer ^{15}N into the tree and it promises to be an effective way to study N transformations and cycling without disturbing tree-soil systems and processes. Most ^{15}N-indirect techniques cause disturbances to the soil or N-pool size as the tracer material has to be physically and homogenously mixed with the soil and the residues, which are usually minced or cut to pieces for convenience. Thus, the most powerful aspect of the direct method is its potential to measure the contribution of a functioning root system to soil processes, without any root excavations. The potential to 'indirectly' label other soil N pools using the direct method, clearly exists, thus, ^{15}N can be traced from tree to litter and finally to soil pools and subsequent crops (Horwath et al.1992). The higher recovery of below-ground biomass N by corn would indirectly imply higher mineralization rate as well as more synchrony between N release and N uptake by corn from *P. falcataria* roots than from *P. falcataria* leaves. Lignin, polyphenols and N content are used as litter quality indicators (Zaharah et al.1999). Plant residues with high N, low polyphenol and lignin are expected to decompose rapidly and are hence termed, high quality. This is in line with findings of other authors (Mafongoya et al. 1998; Briones and Ineson, 1996 and Zaharah et al.1999) that, the ability of residues to improve soil inorganic N and crop N uptake depends on their quality. However, our results vary, suggesting that other factors were more important than residue quality in influencing decomposition rates under uncontrolled weather conditions in this study. When prunings are surface applied the effects of-often harsh-physical environment may override the effects of residue quality (Mafongoya et al. 1997; Swift et al. 1991). One of the major reason of low N recovery from surface applied residue inputs especially in case of soil with relatively high pH such as the one used in this study (pH 6.05 in KCl), is that significant N losses may occur through ammonia volatilization (Mafongoya et al. 1997; Costa et al. 1990). This range of N recovery agrees with the one we obtained concerning unexcavated directly labeled roots. Mulongoy and Sanginga (1990) found that corn crop recovered as low as 15% of the N from high quality surface applied leaves of *L. leucocephala*, but Ladd et al. (1983) found even lower N recovery rates of about 4% from surface applied leaves. Furthermore, our results imply that the use efficiency of *P. falcataria* root residue N by corn was significantly higher ($P<0.05$) than that of *P. falcataria* leaf N, support those of Mc Neil et al. (1997 & 1998), which suggested that the total N deposition from roots may be 2 to 3 times higher than maximum root N. Based on these findings, the use efficiency of *P. falcataria* root-N in this study, would actually work out to be around 30 to 40% instead of a higher percentage of above 90. Such recovery rates have been report by other authors (Giller et al. 1995) but from incorporated above-ground biomass. This suggests that root production and turnover in agroforestry systems practiced on very infertile soils may be more important for nutrient cycling than leaf residues. Mixing of leaves and roots had no significant effect on the amount of N derived from either of them (Ndfr) respectively . This shows that, there were no significant decomposition interactions between *P. falcataria* roots and leaves in the mixture.

Conclusions

Increasing N recovery rates from residues that are used as a source of N to crops is a major challenge of agroforestry cropping systems. Rates of N recovery from below-ground biomass by crops may significantly surpass those of above-ground biomass as shown in this study. However, substantial knowledge gaps remain in terms of below-ground biomass decomposition interactions, including the nature and role of rhizodepositions in as far as soil N dynamics are concerned. Direct labeling of tree biomass proved to be a valuable tool in studying N cycling of above and below-ground biomass. Upon ^{15}N injection into the tree, root exudates to the soil are labeled, the challenge still lies in distinguishing rhizodeposited N from biomass mineralized N. As observed, the 'unusually' high N recovery rate from *P. falcataria* roots in this study may have been as a result of basing N recovery calculations on root total N, yet extra labeled N may have exited into the soil solution from *P. falcataria* roots in form of root exudates subsequent to the ^{15}N injection

Benefits from the study

Nitrogen fixing trees are valuable as a source of nutrients for food crop production. These trees are easy to grow, fast growing and contribute significantly to the nutrients required for food crop growth and production.

Patent(s), if applicable:

Nil

Stage of Commercialization, if applicable:

Nil

Project Publications in Refereed Journals

1. Chintu R and **Zaharah AR**. 2003. Nitrogen uptake of maize (*Zea mays*, L.) from isotope- labeled biomass of *Paraserianthes falcataria* grown under controlled conditions. Agroforestry Systems 57(2): 101-107

Project Publications in Conference Proceedings

1. **Zaharah, A.R.**, Chintu, R and Ghizan.S. 2002. Evaluating residues from Batai trees (*Paraserianthes falcataria*) as an alternative source of nitrogen for grain corn (*Zea mays*., L.) in the humid tropics. Paper presented at International Nuclear Conference (INC 02). Oct 15-18, 2002, Kuala Lumpur

2. **Zaharah, A.R.** and Chintu, R. 2002. Above and below ground nitrogen contribution by legume tree to an associated cron crop. Paper presented at 13th International Symposium of the International Scientific Centre of Fertilizers. 10-13 June 2002, Tokat, Turkey

3. **Zaharah, A.R.**, Chintu, R., Anuar, A.R., Halimi, M.S., and Kadir, W.R. 2002. Nitrogen contribution by a legume tree (*Paraserienthes falcataria*) biomass to a corn crop. Paper presented at Malaysian Soil Science Soc. Conf. Kangar. Perlis. April 23-25, 2002.

4. **Zaharah, A.R.** and Chintu, R. 2002. Measuring the nitrogen contribution by *Paraserienthes falcataria* to corn (*Zea mays*., L). Paper presented at the Malaysian Soc. Plant Physiology Conf. Melaka. 10-12 September, 2002.

Graduate Research

Name of Graduate	Research Topic	Field of Expertise	Degree Awarded	Graduation Year
Richard Chintu	Nitrogen contribution of *Paraserianthes falcataria* tree biomass to corn (*Zea mays.* L) production	Soil Fertility	**M. Agric. Sci**	**2002**

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