Fate of applied N fertilizer in mixed cropping systems in the central Amazon

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Soils of the humid tropics are known to be poor in nutrients and agricultural activities over a long period of time is only possible with the use of fertilizers. Because of the high amount of rainfall nutrient leaching losses are a major concern for nutrient management in the central Amazon (Cahn et al., 1993) in general in humid tropical ecosystems. Mixed cropping systems of trees with different root activity patterns may be able to use applied nutrients more efficiently and reduce unproductive losses through nutrient leaching.

The study was carried out on a highly weathered and aggregated Xanthic Ferralsol with a low cation exchange capacity on the terra firme near Manaus (Amazonia-AM). With an altitude of 50m above sea level, 2600mm annual precipitation and 26° C average temperature the site is situated in the moist tropical lowland rainforest. Aim of the study was to investigate the nitrogen dynamics and the fate of applied nitrogen fertilizer in the soil-plant system of a mixed cropping system consisting of *Bactris gasipaes* Kunth. (peachpalm, Arecaceae), *Theobroma grandiflorum* (Willd. ex Spreng.) K. Schum. (cupuaçu, Sterculiaceae), *Bertholletia excelsa* Humb. & Bonpl. (Brazil nut, Lecythidaceae) and *Bixa orellana* L. (annatto, Bixaceae).

15N tracer (10 atom% 15N enriched $(NH4)_2SO_4$) was applied before the rainy season (January 1999) and its way in the plant-soil system was monitored until the end of the rainy season (April 1999). Leaves were sampled from all investigated trees 14, 36, 69 and 96 days after the isotope application. Samples of the total aboveground biomass and the soil were taken 2 and 14 weeks after the application at 0-10, 10-30, 30-50, 50-80, 80-120, 120-200cm depth (200-300, 300-400 and 400-500cm only at 14 weeks). 20g soil were extracted with KCl and analyzed for NH_4 and NO_3. Additionally, the extracts were destilled and the N isotope composition was measured in the destillates as well as in bulk soils and biomass.

Large nitrate leaching was found underneath all investigated tree species (Fig. 1). A total amount of 7.5% of the applied ^{15}N was found to be leached under the rooting zone (>200cm) fourteen weeks after the application. Under annatto no signifikant ($p<0.05$) nitrogen leaching took place, but under cupuaçu (15.2% of the applied ^{15}N), peachpalm (9.6% of the applied ^{15}N), and brazil nut (4.45% of the applied ^{15}N) relevant amounts of nitrogen were leached into the subsoil at the end of the rainy season. Because of this nutrient leaching we recommend a reduced fertilizer amount (from 39.5 Kg ha^{-1} to 36.5 Kg ha^{-1}) for the mixed cropping system (7-8 years old).

After two weeks the trees took up nearly 26% of the applied ^{15}N and at the end of the rainy season the uptake increased to 47% (Table 1). Annatto and Brazil nut took up a significant higher ($p<0.05$) amount of the applied ^{15}N compared to peachpalm and cupuaçu two and fourteen weeks after application.

2.5% of the applied ^{15}N could not be accounted for in the soil or in the aboveground biomass two weeks after application. After further twelve weeks this amount increased to 25% (Table 1). This nitrogen was presumably lost by denitrification.

Annatto, cupuaçu and peachpalm seemed to take up more than 90% of the incorporated nitrogen fertilizer under their own canopy (Fig. 2). However, Brazil nut took up more than 70% of the fertilized nitrogen

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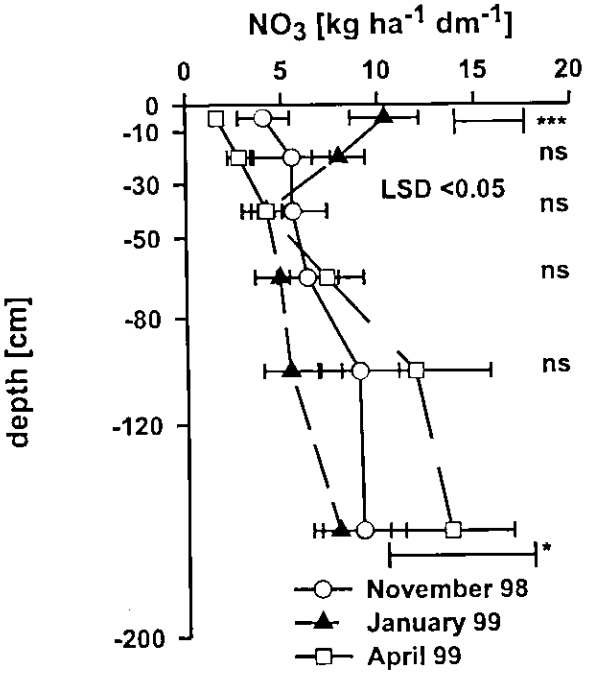
FIG. 1. Dynamics of Nitrat (measured in KCl extracts) in the soil (0-200cm) from the beginning of the rainy season (November 1998) to the end of the rainy season (April 1999); ns not significant, *, *** significant at $p<0.05$, $p<0.001$, respectively; means and standard errors (n=12)



from the fertilized areas under the canopies of the neighboring trees (peachpalm: 40%; annatto: 25%; cupuaçu: 8%) two weeks of the fertilizer application. At the end of the rainy season Brazil nut even took up more than 80% from underneath neighboring trees crops (peachpalm: 42%; annatto: 36%; cupuaçu: 6%). Furthermore, peachpalm and Brazil nut were better able than the other two trees in reducing nutrient leaching due to their deep root system. They took up nitrogen from the subsoil nitrogen pool, which was found under all investigated species as a result of leached tilizer. How much of the nitrogen fertilizer which still remained in the soil after the rainy season would be used by the trees in the long term warrants further research.

References

Cahn, M. D., Bouldin, D. R., Cravo, M. S., and W.T. Bowen. 1993. Cation and nitrate leaching in an oxisol of the Brazilian Amazon. Agron. J. 85: 334-340.

TABLE 1. Recovery of total applied 15N in the biomass of *T. grandiflorum, B. excela, B. gasipaes,* and *B. orellana* and in the air dried soil (0-5m) under these tree species 11 months after the application in April 1999; values in one column or row followed by the same small or capital letter, respectively, are not significantly different at p<0.05; means and standard errors (n=3)

Plant species	Recovery [%] of ^{15}N applied to									
	T. grandiflorum		*B. excelsa*		*B. gasipaes*		*B. orellana*		total area	
T. grandiflorum	2.87 a A	±0.43	0.48 a B	±0.38	0.12 a B	±0.03	0.23 a B	±0.06	3.70 a A	±0.37
B. excelsa	1.02 b A	±0.60	2.72 b B	±0.64	6.93 b C	±2.97	6.09 b C	±3.64	16.76 b D	±4.60
B. gasipaes	0.04 c A	±0.03	0.04 c A	±0.01	3.60 c B	±0.54			3.69 a B	±0.52
B. orellana	0.44 c A	±0.10	0.55 a A	±0.17			22.17 c B	±7.18	23.16 b B	±7.19
Sum of plants	4.38 d A	±0.36	3.79 b A	±0.60	10.66 bd B	±2.79	28.49 c C	±10.7	47.32 c A	±9.76
Soil (0-5 m)	3.10 a A	±0.35	2.97 b A	±0.85	14.94 d B	±1.91	8.33 b C	±1.96	29.34 bc D	±0.68
Total sum	7.47 e A	±0.28	6.76 d A	±0.25	25.59 e B	±2.48	36.81 e B	±9.18	76.65 d C	±9.71

FIG. 2. Foliar 15N dynamics of *T. grandiflorum, B. excelsa, B. gasipaes,* and *B. orellana* from November 1998 (before the application of 15N enriched (NH4)2SO4) to December 1999. The comparison between the four fertilized tree species over time is given by the small letters; values with similar letters are not significantly different at p<0.05; ns not significant, *, **, *** significant at p<0.05, 0.01, 0.001, respectively; means and standard errors (n=3)