No-till and direct seeding into the mulch of legume prunings as a sustainable land-use alternative for the humid tropics

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Introduction

In contrast to the plains of the center-south of Brazil, in the humid tropics, on the edges of the Amazon forest, the technological challenges to establishing and maintaining productive and sustainable agricultural systems do not overcome yet. Firstly, an absence of alternatives for the sustainable management of tropical agrosystems has been caused by weakness in the institutions responsible for the creation and dissemination of technologies in the region. Secondly, because the paradigm of extensive and monocultural agriculture established for the south/southeast regions of Brazil is not adequate for the conditions of a tropical environment; it does not meet the needs of the region's communities of family farmers.

In regions on the edge of the Amazon, such as the northeast part of the state of Maranhão, which are agricultural frontier areas where the original vegetation has already been devastated, there now exists an enormous social block represented by a large contingent of farmers who live below the poverty line. It is not a coincidence that many of the poorest towns in Brazil are located in this region, with human development index ranging between 0.498 and 0.467 (PNUD, 2000). Whether this process continues is of fundamental importance to Brazil because it means that slash and burn agriculture is advancing on the Amazon rainforest, with a negative effect on every dimension of Brazilian national policy. In the global context, it is estimated that 36% of all CO_2 emitted by Brazil (which is one of the world's top 5 countries in terms of emissions) comes from uncontrolled fires, which give off approximately 195 tons of CO_2 for every hectare of forest burned (Fearnside, 2002).

The influences of interaction between climate and local soil on humid tropical agriculture

The biggest challenge for researchers in the field of tropical agriculture is to offer technological alternatives that can sustain agriculture in soils derived from sedimentary rocks that have been subjected to a high degree of weathering. Of a fragile nature and having a low ion retention capacity, these soils cannot support the extensive use that agricultural food production demands, in the way that it is practiced in other regions. On the other hand, there is enormous potential for biological productivity, if there were a way to utilize the solar energy available in the region, which is uniquely privileged over the rest of the world in this respect.

By acting as a dampener on the temperature and humidity of the soil, the no-tillage and the mulch also help to create a habitat favorable to an increase in density and to the activity of the burrowing macrofauna, which can have a positive effect on the root environment by increasing soil porousness and permeability, as shown by Mele and Carter, 1999. In work conducted over a period of two years by Guterres Júnior (2003), on a pre-Amazonian ultisol, no-tillage and an amount of pigeon pea straw, added to the surface, visibly increased the number of annelids and myriapods, the latter being more effected by the levels of mulching (Table 2).

Moura et al., (2008) used a mulch of pigeon pea straw in alley cropping in order to evaluate the effects of the mulch and the tillage on the capacity for aeration and growth in the cultivation of corn, planted between rows of pigeon pea, in a pre-Amazonian Ultisol. This research verified that tillage soil without mulch had a lower capacity for aeration and also lowers levels of plant growth. Recompaction of the uncovered plots, with or without tillage, and the protection afforded by the mulch against rain and in favor of the macrofauna were responsible for these differences. The lower growth levels for no-till plots or plots with more mulch (13.4 $M.ha^{-1}$) were attributed to the overshadowing of the corn by the alleys of pigeon peas placed close to it.

Other experiments, such as those by Leite et al., (2008) and Aguiar, (2006), have demonstrated that no-tillage on straw from leguminous plants cultivated at the same time and in the same space as food crops aids in the promotion of the essential processes that raise and maintain the productivity of crops in the humid tropics, these being: the formation of a litter bed in decomposition with a soil cover and the recycling and retention of nutrient content in the surface layers. To achieve these two objectives, Aguiar (2006) used a combination of plant species with different residue qualities, with those of a low quality being used to cover the soil and those of a higher quality being used to provide nutrients. In three years, the combination of Acacia mangium and Leucaena, with a 4-m separation between rows, added 38 Mg dry material per hectare and recycled 915 kg of nitrogen, 639 kg of calcium and 263 kg of potassium.

Aside from surface liming with 1 $M.ha^{-1}$ of limestone, undertaken during the first year, this recycling allowed the highest levels of saturation to be maintained by the soil base in the bed of 0-10 cm; the uncovered areas had 58.4% lower levels (in the fourth year) in comparison to those plots that received leguminous residues. Better root growth conditions were reflected in the productivity of the corn, which remained at the same unsatisfactory levels over the four years in the uncovered areas, while in the covered plots it rose 2.6 times, and was especially apparent in the increased size of the ears (Table 3).

Alternative technology for agriculture in the humid tropics

The information gleaned from these experiments and others whose results have been previously disseminated affirms that in the management of humid tropical agrosystems, the processes resulting from the interaction between climatic factors and indicators of soil quality must be taken into consideration. In addition, it must be remembered that these interactions manifest themselves in ways that cannot be predicted from the paradigm established in the southeast of Brazil, which is based only on improving the chemical indicators of soil quality.

Given the local conditions necessary to various aspects of sustainability, the UEMA's Agrorecological researchers recommend taking advantage of the rapid growth of plants in the tropics through a "*no-till in alley cropping system using leguminous mulch*." This system offers the following advantages, among others: i) it brings together, in the same space and at the same time, the processes of cultivation and the regeneration of soil fertility; ii) it allows for leguminous plants of high and low residue quality to be combined for the purposes of soil cover and nutrient recycling; iii) it facilitates the maintenance and even increase of the soil's organic content; iv) it reduces the need for external input because it dispenses with the need to saturate the soil with soluble nutrients; and it facilitates the development of mineral reserves, made available and accessed through measurable microbiological processes. In practice and in conjunction with farmers, this system offers the best results with the planting of crops in alternate strips in order to assure discontinuous substrata for avoiding and spreading pests and diseases.

In this situation, the simultaneous planting of an annual legume with good tolerance for drought is recommended in order to occupy the area after the second harvest, with the aim of reducing the incidence of damaging weeds in the following year. The strips that are planted with crops having medium-length cycles, like corn and rice, can be used again for a second cropping of short-cycle cultivars, such as beans or sorghum.

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Table 1 Comparative effect of bases saturation percentage and of soil cover with 3 Mg ha^{-1}, on the parameters of corn production in the pre-Amazonian region.

Yield parameters	Bases Saturation Percentage				CV
	73		28		
	Cover	Uncover	Cover	Uncover	%
Mean ear weight, g	134,0a	89,9c	112,3b	79,5c	11,6
100-kernel weight, g	26,2a	21,6b	24,9ab	20,7b	14,3
Biological yield, kg ha^{-1}	8.854a	6.121b	7.070b	4.674c	13,7
Total grain weight, kg ha^{-1}	4.281a	2.837c	3.501b	2.238c	13,6

Means followed by the same letters in the row do not differ from each other ($P < 0.05$, Tukey test). CV = coefficient of variation

Table 2. Density (number m^{-2}) of annelids (A) and myriapods (M) in a pre-Amazonian Ultisol, after two years of cultivation with mulch.

Mulch, (Mg ha^{-1})	Soil Management				Mean	
	No-till		Till			
	A	M	A	M	A	M
2,0	5,75	1,75	5,00	1,50	5,38b	1,62ab
2,5	10,00	1,50	7,25	0,75	8,62ab	1,12b
3,0	15,50	2,25	8,25	2,75	11,88a	2,50a
0,0	2,75	0,00	2,00	0,00	2,38c	0,00
Mean	8,50 A	1,37 A	5,62 B	1,25 A	2,32	1,23

Means followed by the same letters in the column do not differ from each other ($P < 0.05$, Tukey test).

Table 3 Evolution of the content of Ca, Mg, bases saturation percentage, ear size and total grain mass in soil cultivated with residues of Leucaena mixed with Acacia (L+A) and uncovered soil (US).

	Ca		Mg		Bases Saturation Percentage		Mean ear weight		Total grain weight	
	------ $mmol_c$ dm^{-3} -----				--- % ---		----- g -----		-- Mg ha^{-1} ---	
	US	L+A	US	L+A	US	L+A	US	L+A	US	L+A
2003	14.5	14.4	10	10.2	68.0	67.0	53	48	1.32	1.24
2004	14.5	14.7	10	11.0	67.5	66.0	32	41	1.54	2.58
2005	11.5	15.5	2	2.5	35.0	39.5	72	89	1.84	2.66
2006	6.0	16.0	1	2.5	21.0	46.5	68	110	1.50	3.20