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*Full length Research paper*

# Soil-root interface (RLD), porosity and density of earthworms in crop profile, under young agroforestry fallow-grassland (Green Mat), in Kisangani (DR Congo)

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**An experiment was carried out in Kisangani (DR Congo) to examine, faced to the Slash-and-burn system, to what extent and what degree the cropping system in "Plates under Green Mat" would favorably affect the soil-root interface (RLD), porosity and soil macro-invertebrates including earthworms. A device plan with 5 completely randomized blocks, divided into 2 plots each, was chosen to test the factor "production system (single-factor ANOVA x Duncan's test)". It emerges from this study the following performance points:**

- ✓ **An improvement in root density and soil-root interface (13.4 versus 5.2 g/100 cm3 of soil and 22.2 versus 8.9 cm/cm$^3$ at 0-5cm), the effects ranging up to a depth of 20cm ;**
- ✓ **A dense and more compact rooting board, suitable for mineral recycling and for the complete redistribution of edaphic bioagents for fertility improvement, both microbial and faunal ;**
- ✓ **An improvement in structure and organicmatter rate of the upper soil strench (8 against 3.5% at 0-5cm and 4.5 against 1% at 5-20cm);**
- ✓ **An improvement in earthworm density of 200% (1693 against 581 /m$^2$).**

**Cropping in Plates under Green Mat thus displays the essential features of Conservation Agriculture, being both ecological and sustainable.**

**Key words :** Green Mat, Slash and Burn, rootingboards, morpho-edaphic charts, Soil-root Interface, Lombrics

## INTRODUCTION

Conservation farming practices promote the safeguard and improvement of soil resources, ensuring sustainable management of agroecosystems (Mulatie, 2021). In this way, zero or reduced cultivation methods are used, which are there fore likely to promote both pore balance, humus content and microbial and faunalbiodiversity, through a considerably improved soil-root interface (Lal, 2010 ; Cooper *et al,* 2020). No-till, while promoting C sequestration and conservation of soil resources over time, leads to increased resistance to root penetration (Arvidsson *et al,* 2013), affecting root development and the infiltration coefficient (Bayat *et al,* 2013), this being controlled with biochar incorporation (Obia *et al,* 2020).

Minimum tillagewith residue retention (Modak *et al,* 2020),on the other hand, makes it possible to relatively circumventthese limitations while safeguarding the essential advantages of no tillage (López-Fando and Pardo, 2012), more particularly an increase in microbial activity (López-Garrido *et al,* 2012) and the diversity of biological functionalities in the mycorrhizosphere (Nautiyal *et al,* 2010; Li*et al*, 2021). It also has significant potential in improving the physical and

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biological properties of the soil (Hartmann *et al,*2012) and the suppression of weeds; this without a formed plow sole or any detrimental effect on root growth (Vakali*et al,* 2011).

Also, it has been found in Canada that the use of no-till does not always lead to improved yields. The effectiveness of the system being there fore linked to many factors including the climate, the history of land management, the nature of the soil, the topography and the position of the field on the water shed (Blaise, 2011;Rosolem and Calonego, 2013).

In addition, it was pointed out that terraces and isohypse living hedges effectively counteract runoff on undulating and steeply sloping land so common in tropical environments. Erosion control is considered an essential condition for the establishment of efficient agriculture (Comino *et al,* 2010), sedentary and ecologically compatible with tropical conditions where the soils are rugged, undulating and always sloping (Rodenburg*et al,* 2003) ).

Establishing permanent isohypse grass bands, as old as 20 years, has been shown to be particularly effective in maintaining fertility under a diverse range of edaphic and topographic conditions (Kagabo*et al*, 2013).

The ecological disadvantage of conventional tillage is that it disturbs the soil structure, thus imposing restrictions on the movement and feeding of earthworms (Johnson *et al,* 2007).

This modifies the composition and structure of microbial communities, which are correlated with soil micromorphology (Gupta and Roper, 2010;Helgason *et al,* 2011 ; Jiang *et al,* 2011).

In a long-term trial to determine the role of earthworms in different cropping systems earthworm droppings played a major role in the mixing of horizons, the establishment of gas and material exchange galleries between horizons and the integration of the carbon of organic inputs with that of the mineral phase of the soil (Bottinelli *et al,* 2010 Zhang *et al,*2011; Arai *et al,* 2013).

According to Karlen *et al*. (2019), Soil biological properties and processes are the new frontiers in soil health. Mulching and no tilldevelop a high potential in C sequestration (Fiorini *et al,* 2020).

Finally, soil structure largely affects productivity at the field level. Measurements of the hydraulic conductivity at saturation, also linked to the structural state of the soil, make it possible, with a view to precision agriculture, to quickly identify and locate, or evenmap, sectors of low primary productivity or low biological activity over the entire cropping landscape (Keller *et al,*2012; Kahle *et al,* 2013; Karlen *et al,* 2013; Thierfelder *et al,* 2013).

Ultimately, we are led to ask the following question : "to what extent and to what degree the Green Mat system, through its dense permanent root structures and minimum plowing that does not disturb the soil, favorably impact soil-root interface (RLD), porosity and soil macro invertebrates including earthworms ? "

## MATERIALS AND METHODS

### Site Location

The experiments were carried out in the research station of the Faculty of Renewable Natural Resources Management of the University of Kisangani (Faculty of Sciences concession) located in the Municipality of Makiso, city of Kisangani.

The test site islocated at 404m altitude, 00 ° 30'05 "North latitude and 25 ° 12'41" East longitude. The slope of the terrain, which is highly variable, is 8.5% upstream, 3.6% downstream and 16.1% at mid-slope. Also, the tests under taken extend fromJanuary 2008 to December 2012.

### Vegetation

The vegetation of Kisangani is located in the central forest sector of the Guinean region, characterized by dense humid forests and various vegetation groups degraded as a result of human action (Mate, 2001). The hinterland of the city of Kisangani was initiall ycovered up of evergreen rainforests which constituted its climax. Currently, under the effect of degradation due to increasing pressure, these forests have given way to highly disturbed recruits, low herb aceous fallows and crop fields.

The experimental site had a previous cropmarked by the continuous cultivation of cassava associated with maize.

The short-lived fallow areas were dominated by *Cynodondactylon* with sparse patches of very dense *Panicummaximum*, *Puerariajavanica* and *Calopogoniummuconoides*. The lowland area along the stream was dominated by *Pennisetumpurpureum*.

## EDAPHO-CLIMATIC CONDITIONS

The soil of Kisangani (Fac. Des Sciences UNIKIS) carrying the agroforests evaluated presents, upstream, a heavy clay-silt-sandy texture with 42%, 30% and 28% of elementary particle content, respectively for clay, silt and sand.

The texture, downstream, is more variable but overall of a heavy to very heavy nature. The textural triangle used is from the Applied Pedology Problems Study Group, GEPPA. Table 1 below gives the chemical and physicochemical properties of the soil at the start of the study.

The city of Kisangani enjoys an equatorial climate of type Afaccording to the Koppen classification. It is a constantly hot and humid climate, thus identifying itself with a very high ecological productivity. The average annual precipitation is therefore around 1800 mm, with average daily temperatures varying between 24 and 25°C. However, a considerable increase has been observed over the past 5 years, wit hannual rainfall reaching 2000-2400 mm and the average monthly temperature reaching 27-28°C. Figure 1 below shows the essential climatic data during the test period.

## EXPERIMENTAL APPARATUS

The experimental device mounted in this study is given in figure. 2 below. The experimental sector, linked to the rain fed rice cultivation was practiced under the fallow-green manure of *Mucuna –Pennisetum*. It was established upstream of the water shed, on a sloping land (8-9%) with a direction slope from South to North.

**Table N ° 1. Characterization of the soil at the end of the preliminary phase (morpho-edaphicoptimization) in March 2011, before the start of the final phase of the experiment ****

| Systèmes de production | CO (%) | P assimilabl + P organiqu (mg/kg sol) | $Al^{3+}$+$H^{+}$ (cmole/ | Satu-ration $Al^{3+}$ (% | Satura-tionen bases % | Bases totales (cmol/kg) | $K^{+}$ cmole | $Na^{+}$ Cmole / kg | $Ca^{2+}$ Cmole / / | $Mg^{2+}$ Cmole kg | N (%) | pH au Kcl | pH à H | ECECcm / / k |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Strate de sol de 0 à 15 cm de profondeur | | | | | | | | | | | | | |
| Tapis vert | 4,5 | 86 | 5.2 | 47.3 | 52.7 | 5.80 | 2.20 | 0.10 | 2.10 | 1.40 | 0,3 | 4,4 | 5.3 | 11,0 |
| Abattis-brûlis | 1,5 | 37,2 | 15.6 | <u>87.6</u> | 12.4 | 2.18 | 0.30 | 0.06 | 1.34 | 0.48 | 0,16 | 3,5 | 4.3 | 17,8 |
| hamps voisins | 0,3 | 25,0 | 17.6 | <u>90.8</u> | 09.2 | 1.77 | 0.20 | 0.06 | 1.13 | 0.58 | 0,08 | 3,5 | 4.1 | 19,4 |
| | Strate de sol de 15 à 30 cm de profondeur | | | | | | | | | | | | | |
| Tapis vert | 1,1 | 26 | 17.6 | <u>91.6</u> | 08.4 | 1.59 | 2.2 | 0.1 | 2.1 | 1.4 | 0,08 | 3,8 | 4.6 | 19,2 |
| Abattis-brûlis | 0,4 | 19 | 19.8 | <u>94.3</u> | 05.7 | 1.02 | 0.14 | 0.04 | 0.72 | 0.12 | 0,07 | 3,4 | 4.1 | 21,0 |
| Champs voisins | 0,2 | 13 | 23.0 | <u>96.0</u> | 04.0 | 0.94 | 0.10 | 0.03 | 0.69 | 0.12 | 0,05 | 3,3 | 4.1 | 23,9 |

*** The underlined values of the aluminum saturation are thosewhich do express the aluminumtoxicity, the threshold of whichis set at 60%.**

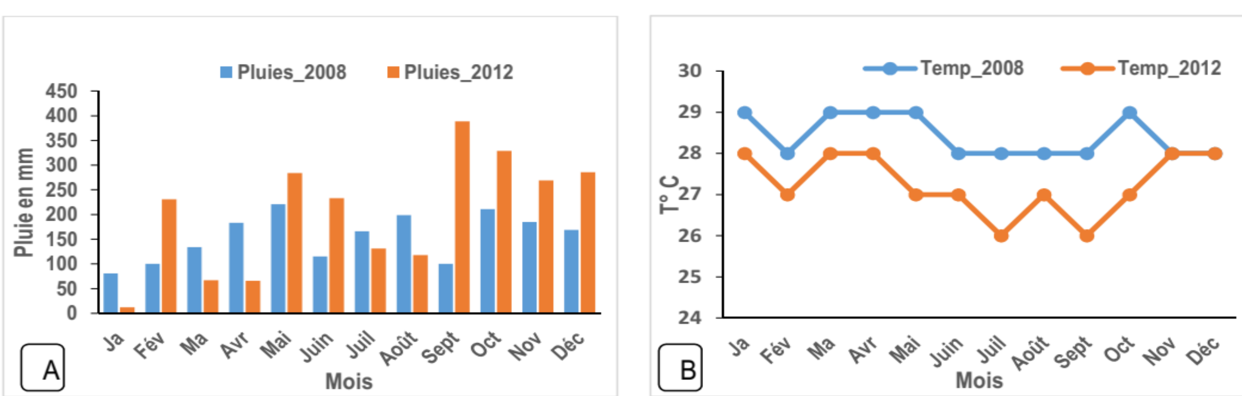



***Fig. 1 (A, B). Evolution of monthly average temperatures and rains at the experimental site, between 2008 and 2012 (data from the first and last year of the study). Source: IFA, Department of Plant Science.***

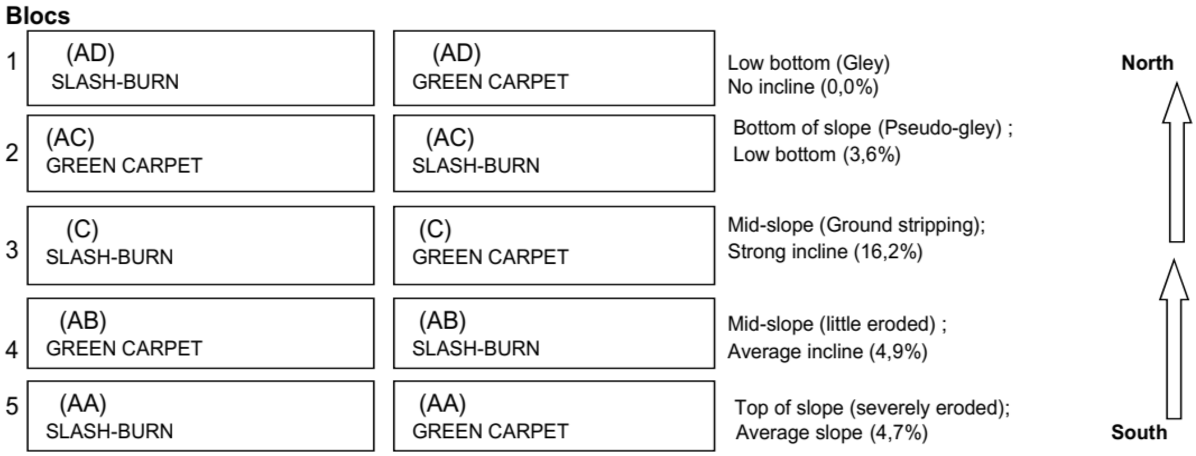



***Fig. 1. Experimental device testing on soil-root interface, porosity and density of erthworms under agroforestry fallow-grassland, faced to slash-and-burn cultivation.***
***Legend: AA, AB, AC, AD and C designate the different experimental blocks. The plots form blocks perpendicular to the slope, the latter facing from South to North. The factor "morpho-edaphic properties" varying from one block to another (position, slope) was not taken into account at this scale of analysis. ⟹ Direction of slope.***

## SHORT APPROACH

The entire process to carry out this study took place in the field, on the one hand, and in the laboratory of soil analysis, on the other. It all started with the establishment of improved fallow to restore soil fertility.

### Establishment of fallows with *Mucuna-Pennisetum* for green manure

Fallow fields with *Mucuna-Pennisetum* intercropping green manure were established on each of the plots of the device on the "Green Mat" system. Bush slash was carried out by clearing-stumping operation with a machete at ground level. Each plot was crossed by 8 lines of *Pennisetumpurpureum*, the latter being established at spacings of 50 x 50cm, thus observing a holes pace of 25 cm on either side. A line of *Mucunapruriens* was then inserted, established in pockets (2 grains) made with a hoe every 100 cm.

Manure (10t DM/ha) and microdoses of NPK fertilizer (50kg /ha) were applied. This ultimately produced "the raw mulch-compost "fertilized in situ which is the first stand for the "rhizo-bio-organic mat layer", used as the main strategy of mineral capitalization, maintaining a rapid setting in circuit and a continual mineral recycling. Root profile samples were used to assess root production by the treatment plot.

### Evaluation of soil texture

The texture was determined for each of the stratified sectors, thususing composite samples addressing the soil slice 0 to 15 cm deep. It was determined by the successive sedimentation method, according to Baert and Van Ranst (1998), using sodium hypochlorite for the removal of organicmatter.

### Spatial structure of the rooting of agroecosystems (RLD and RMD) under fallow

This investigation included 2 expected results, namely (1) the change in root density in the depth of the soil (the root density profile) and (2) the rooting board (root density reported on all elementary surfaces of the soil plot) characteristic for each of the fallow-pasture systems confronted. *P. purpureum* has a high potential for root production, to the point of forming a hairy mat, with very beneficial physical and biological properties in the restoration of severely degraded soils.

Slices or blocks of soil measuring 30 x 9 x 3 $cm^3$, or 810 $cm^3$, were carefully removed using a root auger, due to two quadrants of 1$m^2$ delimited at random, per experimental plot sampled in each of the 2 production systems, out of all 5 blocks in the device.

The blocks of soil brought back to the laboratory were wetted, subdivided into 5cm slices, sprayed manually and subjected to a laborious work of extraction, counting and measurement of the roots, according to the operating procedures followed by Lopez-Zamora *et al.* (2002) and Kashiwagi*et al.* (2006). After calibration and lath measurement (RLD), the extracted roots were subjected to drying in an oven at 105°C, to constant weight (RMD).

### Physical and morpho-edaphic properties of agroecosystems

Morpho-edaphic charts were produced, based on the development, description and interpretation of 20 crop profiles in the field, 10 foreach of the 2 systems. This, while using a magnifying glass and a camera sparingly to bring out the details better and continue the work calmly in the laboratory. The description of the crop profile and the development of morpho-edaphicpicturewerecarried out according to Jones (2006). From each crop profile was determined a morpho-edaphic board and a root board from which the global average was identified.

**Earthworm count in the fallowcrop profile**

The operation began by taking the temperature of the soil under the litter at the various sites. The samples were taken according to Mulotwa (2001), in accordance with the manual sorting method recommended by the Tropical Soil biology and Fertility (TSBF) program.

Twenty crop profiles, of whichten per cropping system have been developed (2, diagonally, per plot), each highlighting, in its center, a monolith (block of earth) of 25 cm x 25 cm x 30 cm equivalent approximatelyto 30 kg of soil. The monolith was subdivided into four quadrants, the results of which were counted separately. Three 10 cm slices of soil were distinguished on each of the quadrants to facilitate the subsequent manual sorting.

The monolith was thus explored from top to bottom, passing successively through 4 strata, namely (1)> 0 cm, (2) 0 to 10 cm, (3) 10 to 20 cm and (4) 20 to 30 cm. From there, a total per quadrant, then per $m^2$ of floor area was produced at the end of each operation.

**Evaluation of bulk density and porosity at harvest of rice**

The bulk density and the porosity of the soil, on the different plots, were determined for the first 2 slices of 5 cm of soil. The operation was carried out according to the harvest scheme, using several sets of 100cc Koppéky cylinders and a cylindrical mount with a piston to drive it into the ground.The curent operations involved drying these samples at 105°C in an oven, punctuated by several weighing up to constant weight.

**Assessment of root density (RMD) and soil-root interface (RLD) at harvesting of rice**

The two investigations were coupled. The same 100cc Koppéky cylinder mounted on an auger was thus used both to take the soil and the rice roots distributed over the 4 slices of soil, namely 0 to 5 cm, 5 to 10 cm, 10 to15 cm and 15 to 20 cm deep. Root extraction and weighing were performed after assessment of bulk density.

Thus, 20 profiles were drilled per cropping system, therefore 4 in diagonal per plot, or a total of 80 cylinders of soil sampled for the system of "Cropping in Plates under Green Mat" and as many for the system of Slash-and-Burn. The root profile data (RMD) being expressed in g of DM per $100cm^3$ (5 cm strata) of soil, the root productivity of rice in t of DM per hectare and the root density profile (change in root density with successive soil strata) had to be converted by calculation.

**Statistical analyzes**

The data collected on cards, in the various tests described below, were organized and processed first on Excel software sheets. The statistical processing which followed made use of Statgraphics software. The majority of parameters that have been studied in thisdevice have recourse, in turn, to two-factor ANOVA, for the significance of the differences between treatments, coupled to the Duncan's test for their discrimination.

## RESULTS AND DISCUSSION

**The root density and the soil-root interface (RLD) of the agrosystems**

The related data are illustrated in Figures 3, below.

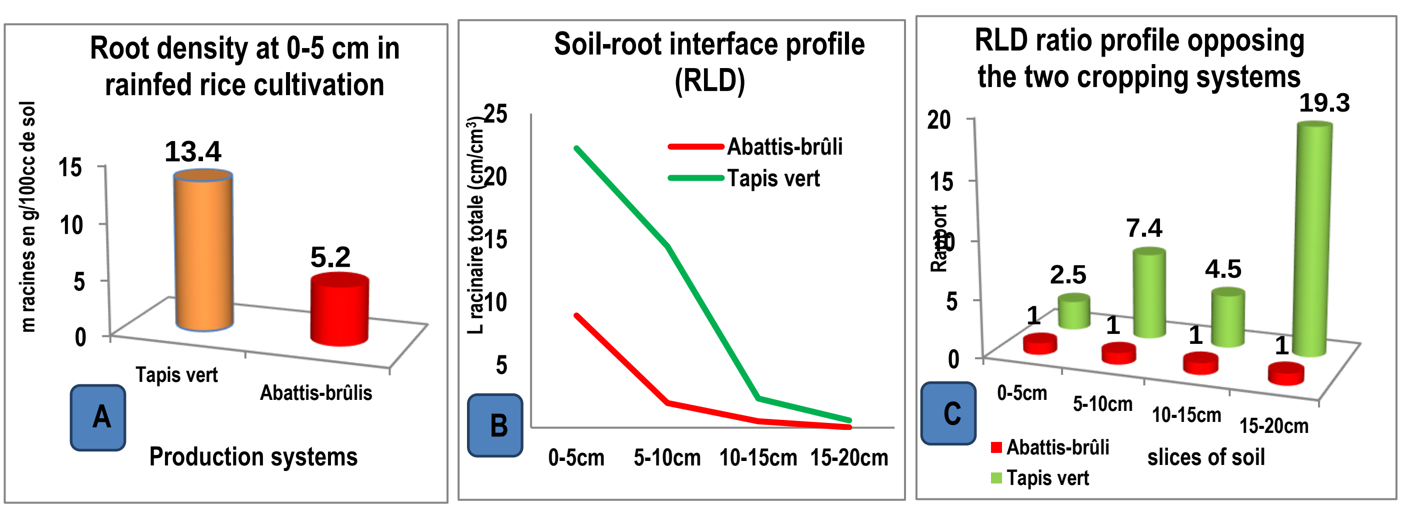



*Figure. 3 (A, B, C). Root density at 0-5 cm (A), soil-root interface profile (RLD) (B) and RLD ratio profile (C) in rainfedrice cultivation (average) opposing the cultivation systemunder green mat and slash-and-burn cultivation. PA = 0.0000; PB = 0.0000; PC = 0.0000.*

It emerges from figures 3A and 3B that "Green Mat" (Tapis Vert) presents versus "Slash-and-burn" (Abattis-brûlis), for the 0-5 cm slice of soil, amuch higher root density and soil-root interface ($p < 0, 0001$), respectively 13.4 versus 5.2 g/100 $cm^3$ of soil and 22.2 versus 8.9 $cm/cm^3$.

Figure. 3C, for its part, reveals that Green Mat presents a soil-root interface 2.5, 7.4, 4.5 and 19.3 times higher, compared to Slash-and-Burn, respectively for strata 0-5, 5-10, 10-15 and 15 -20 cm deep. This would justify the high performance of the "Green Mat system" in that the 2nd and 4th stratum play a crucial role in plant nutrition during dry episodes, for the relative availability of nutrients and water they display, respectively. Below are the performance factors mentioned by different authors.

1 The grassland effect specific to Conservatory Agriculture :crops and meadows managed under zero tillage develop high root densities and hydro mineral demands, often creating stressful conditions (Herold *et al,* 2014) and proving to be more exhaustive, more efficient in the use of nutrients(Carvalho *et al,* 2012), specifically recycling of phosphorus (Yang et al, 2020) than those under plowing ;

2 The prevalence of a more increased mycorrhizal colonization under marginal conditions, in conservation agriculture, givingrise to a higher phosphatase activity in response to increasing metabolic needs (Stover *et al,* 2012);

3 Therole of the fallow root system as a factor of pedogenesis (Lehman and Rillig, 2013): porosity, structural development and biological activity are thus strongly correlated with root density (Lehmann *et al,* 2013; Uteau *et al,* 2013; Mc Kenzie, 2013 ; Parihar et al, 2020);

4 Root grow this accelerated by the methods of balanced fertilization applied to the base of the crop, in the immediate vicinity of the roots (Peigné *et al,* 2013) or incorporating rock fragments (Ceacero *et al,* 2020);

5 The primordial role of root exudates as a factor for sequestering $Al^{3+}$ ions and attenuating toxicity, stimulating biologica lactivity and desorption of inorganic phosphorus, in conjunction with the rhizosphericmicroflora (Ayoubi*et al*,2012 ;Castellany*et al,* 2012).

The fallow-green manure has thus played a capital role in improving the physical, chemical and biological properties of the soil, according to the multi-functional activity of the vigorous and multi-branched root system of *Pennisetumpurpureum*, with a high potential for soil shearing (Comino and Druetta, 2010).

**Density of earthworms and soil porosity in the profile of agrosystems**

The related data isillustrated in Figures 4.

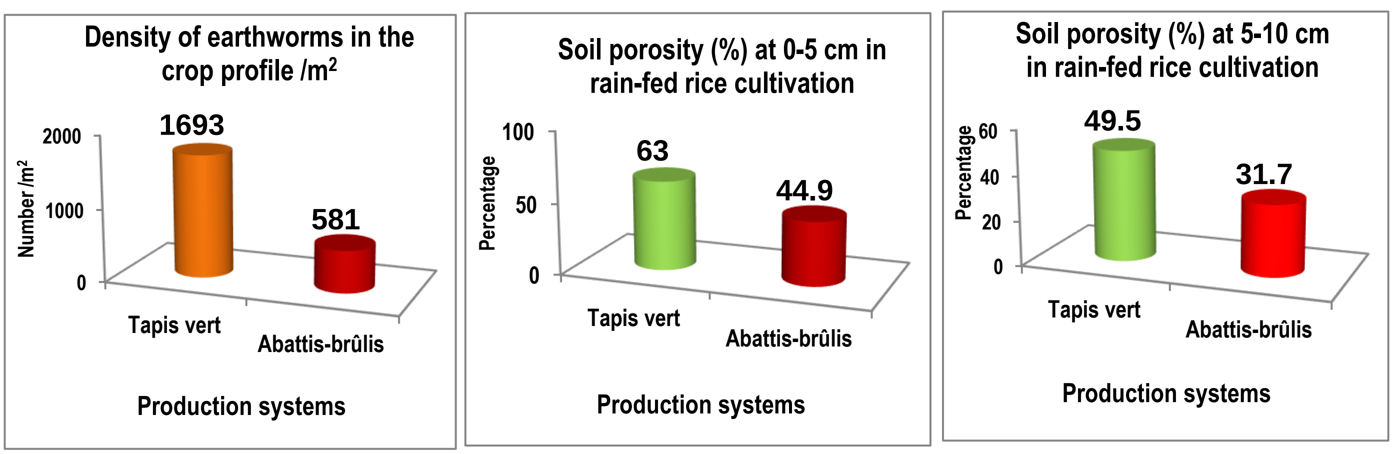



Figure. 4 (A, B, C). Density of earthworms in the crop profile (A) and soilporosity at 0-5 cm (B) and 5-10 cm (C), in rain-fedrice cultivation opposing the systems of cultivation under green cover and slash-and-burn cultivation. The statisticalprobability : PA = 0.0000; PB = 0.0000; PC = 0.000

It emerges from figures 4B and 4C that the porosity under rice cultivation is improved by 40% and 56% for the 0-5 cm and 5-10 cm strata ($p < 0.0001$) when we pass from "Slash and burn" to"Green Mat". We also notice that this improvement brings the porosity of the subcultural layer back to an average value clearly exceeding that reported for the surface layer under Slash and burn. The density of earthworms in figure 4A is 581 and 1693, respectively for Slash-and-burn and Green Mat system ; an increase of nearly 200%.

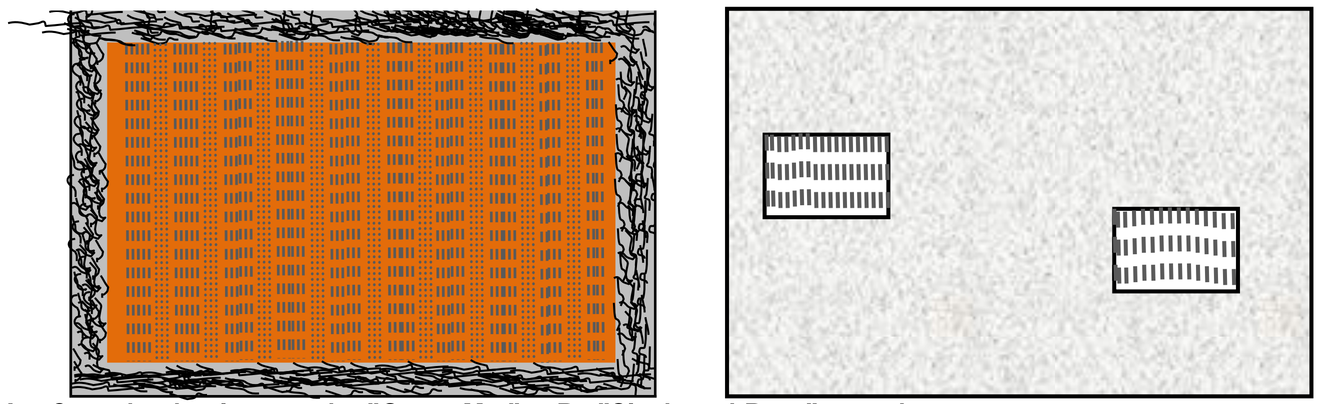
A variable density of earthworms is reported by several authors comparing zero tillage to conventional tillage: 80 versus 49 (Norgrove *et al,* 2011), 81 versus 52 (Xu *et al,* 2013), 319 versus 61 (Errouissi *et al,* 2011), 572 versus 280 (Schmidt *et al,* 2003). The high densities of earthworms recorded in this experiment are attributed to favorable climatic conditions, to the heavyclay-silt-sandy texture, to methodological care (manual exploration-disintegration of soil monolith) but also and above all to the high production of recyclable inputs and root exudations from perennial roots (Phillips *et al,* 2012) under fallow-grassland with *Mucunapruriens* and *Pennisetumpurpureum.*

Also, the balanced application of organic inputs from grass-legume stands stimulates the activity of earthworms, therefore influencing aggregate dynamics and macroporosity (Erikson *et al,* 2009; Jouquet *et al,* 2012). The porosity in these surface strata is linked to the aggregating activity of roots / edaphic bioagents (soil shear potential) including earthworms (Sileshi and Mafongoya, 2006 ; Li et al, 2021).

Although, many factors can contribute to aggregation (microbial juices, extra radical mycelium of CMAs, root excreta), the action of earthworms remains the most determining, making more effective the multi-faceted contribution of labile substances (BMC, BMN) emanating from metabolism (Norgrove *et al,*2011; Al-Maliki and Scullion 2013 ; Xie et al, 2021).

**Average rooting boards and morpho-edaphicbeds of agrosystems**

The related data isillustrated in Figures 5 and 6.



**A. Cropping in plates under "Grean Mat" B. "Slash-and-Burn" cropping**

***Fig. 5. Averagerootingboard for the twoagroecosystemscompared.***

**Legend**

10 à 20 kg/m²/10cm (Tapis vert permanent : hautes herbes) : enracinement très dense

5 à 10 kg/m²/10cm (Lignes de hautes herbes dans l'assiette culturale et touffes isolées): dense

1 à 5 kg/m²/10cm (Interlignes d'herbe dans l'assiette culturale) : enracinement moyen

0 à 1 kg/m²/10cm (Jachère traditionnelle) : enracinement très faible à inexistant

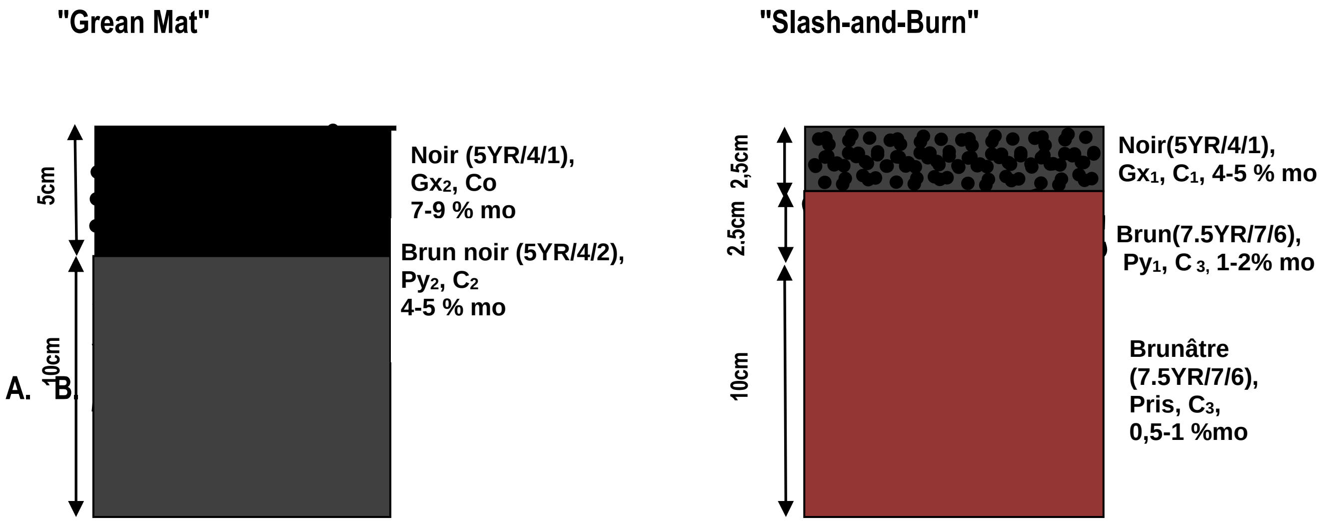



***Figure.6. Average morpho-edaphicbeds of the twoagrosystemscompared (depletedsoil)***

**Legend** Structure **:**

$Gx_1$ : less distinct lumpy structure
$Gx_2$ : verylumpy structure
$Py_1$ : less distinctblocky structure
$Py_2$ :veryclearblocky structure
Pris: prismatic structure

Compactness **:**

$C_O$ : verylowcompactness (. DA : 0,8-1,0 g/cc
$C_1$ : averagecompactness. DA : 1,1-1,2 g/cc
$C_2$ : high compactness. DA : 1,3-1,4 g/cc
$C_3$ : very high compactness. DA : 1,5-1,9 g/cc

From the analysis of the average rooting boards of agrosystems, presented in figure 5, it appears that the Green Mat system presents a very dense rooting along the greenfull grass-shrub mat surrounding the cultivation areas or micro basins, becoming dense to moderately dense in these, respectively on the lines and interlines of the perennial grassy root structures established there.

The slash-and-burn system has very weak to non-existent rooting, except under the tufts of perennial grasses which establish themselves there sporadically in the inter-campaign. In the Green Mat system, the herb-shrubby green mat, which is gramino-leguminous in nature and forms the backbone of the system, thus unfolding in an alveolar spatial configuration. It can thus, thanks to a vigorous, stratified root conformation, claim the high anti-erosion potential, production of biomass and maintenance of soil-root interactions observed in this technology.

From the analysis of the morpho-edaphicbeds in figure 6, it appears that the cultivation system under green mat presents, in the most superficial 15 cm section of the soil, a more elaborate crop profile: for the 0- 5 cm stratum, a black soil (5YR / 4/1) with a very lumpy structure, zero to very low compactness (DA = 0.8-1.0 g / cm3) and rich in organicmatter (7-9%) ; for the 5-15 cm stratum, a brown-black soil (5YR / 4/2) with a very clear blocky structure, compact (DA = 1.4 g / cc) and rich in organicmatter (4- 5%).

The slash-and-burn system presents a very thin crop profile with a black organomineral layer confined to the most superficial 2.5cm, with a less distinct lumpy structure, of average compactness (DA = 1.1-1.2 g / cm3) and of an average richness in organicmatter (4-5%), while the 5-15cm stratum comprises an undisturbed, brownish soil (7.5YR / 7/6), with a prismatic structure, very compact (DA = 1.5-1.9 g / cm3) and verypoor in organicmatter (0.5-1%).

Below are implications related to the morpho-edaphic transformation potential of Green Mat system.

1) The integration in the rotations of fallow-green manure gramino-legume has made it possible, in severa lregions, to improve the nitrogen and carbon content, as well as the depth of the arable soil (Li *et al,* 2010).

2) Long-term continuous cropping of soybean or constant use of legume cover crops is comparable to crop rotation in mediating microbial abundance **/** diversity while decrease the relative abundance of pathogenic fungi (Liu *et al,* 2020)

3) The isohypse establishment of permanent and dense herbaceous shrub hedges, to produce mulch in situ, to counter erosion and runoff and to enrich the soil with organicmatter, is a practice which has proved its

worth in conservation agriculture (Tesfuhuney *et al,* 2013).
4) Zero-tillage practices bypass structural disturbance under cultivation and are more interesting in the tropics where recycling of C and N from microbial biomass is found to bevery rapid, thus granting greater efficiency to fertilization practices relying on organic inputs (Pandey*et al,* 2010; Ding *et al,* 2013).
5) It is evoked in conservatory systems, the concept of stabilization of labile organiccarbon in micro aggregates, within the conglomerates "clay - iron-aluminumsesquioxides" of Ferralsols, especially when green manures, composts and biochar are used (Conceiçao*et al,* 2013 ; Głąb*et al,* 2020).
6) Tillage practices with different soil disturbance shape the rhizosphere bacterial community throughout crop growth, with implication on crop yield (Wang *et al,* 2020)
7) According to Séguy *et al,* (2002), the comparison of the forest ecosystem and the most efficient DMCs (direct seeding under mulch/plant cover), from the most reliable agricultural indicators such as organic%C, the annual biomass of the litter and its rate of mineralization, the root biomass and its ability to use rain water, shows that, apart from the biodiversity criterion, the operating modes are comparable.
8) A recent approach is the development-description of a cultural profile of the soil by visual diagnosis, to anticipate the functioning of the soil under different crops and to make projections on yields. (Lal, 2010; Sierra *et al,* 2013; Fuji *et al,* 2013).

## CONCLUSION

The following performance points emerge from this study comparing the system of "Cropping in Plates under Green Mat" with the traditional slash-and-burn system:

✓ An improvement in root density and soil-root interface for the 0-5 cm soil strench (13.4 versus 5.2 g/100 $cm^3$ of soil and 22.2 versus 8.9 $cm/cm^3$), this difference being more marked in the 5-10cm and 15-20cm strata; This justifies the high productivity of the Green Mat system, especially since the 2nd and 4th stratum play a capital role in plant nutrition during dry episodes, for the relative availability of nutrients and water that they display, respectively;

✓ A dense and more compact rootingboard, suitable for mineral recycling and for the complete redistribution of edaphic bioagents for fertility improvement, both microbial and faunal;

✓ An improvement in the structure and rate of organicmatter of the surface soil (thick layer of very distinct lumpy structure, of zero to very low compactness, at 7-9% organicmatter content versus a very thin layer with a less performed blockystructure ,very compact, and 3-4% organicmatter content);

✓ An improvement in the density of earthworms (1,693 against 581 / m2), ie an increase of nearly 200%.

This has a very favorable impact on the soil-root interface (root board), porosity, the humus rate and soil macro invertebrates including earthworms. Cultivation in Plates under Green Mat thus displays the essential features of Conservation Agriculture, both ecological and sustainable.

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