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Full length Research paper

Rain-fed rice yield and agronomic properties of adepleted Ferralsol, in restoration under an innovative eco-agriculture system: "Cropping in Plates under Green Mat"

Pyame MLD[1 *], Utshudi DJB[2], Haesaert G[3] and Baert G[3]

*[1]Faculté de Gestion de Ressources Renouvelables, Université de Kisangani, BP 2012, Kisangani, RD Congo.
[2]Instut Supérieur d'Etudes Agronomiques de Yatolema, RD Congo ;
[3]University of Gand, Belgium.

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An experiment was carried out in Kisangani (DR Congo) ona depleted Ferralsol to examine, faced with the Slash-and-Burn system, to what extent and what degree the system of cultivation in "Plates under Green Mat" would favorably affect the yield of rainfed rice and the restoration of fertility. A device with 12 complete randomized blocks, divided into 6 plots each, was chosen to test the factors "production system" and "increasing microdoses of NPK fertilizer" (two-factors ANOVA x Duncan's test).
Green Mat system clearly showed gigantic performances:

- ✓ **2.6 times higher yield both for paddy rice, overall production including crop residues and root inputs (5.6 versus 2.2 t/ha, 44.7 vs 17.5 tMS/ha and 16.8 vs 6.5 tMS/ha, respectively);**
- ✓ **a significant reduction in the temperature of the surface soil and a very strong repression of cropping weeds (from 32.2°C to 23.8°C and from 3.9 tMS/ha to 0.6 tMS/ha);**
- ✓ **a lifting of aluminum toxicity, after 2 years of eco-agriculture (integrated mineral-organic fertilization), affecting 90% of the plots vs only 10% with Slash-and-burn.**

The agronomic properties analyzed show, on average, a variance controlled at 80-95% by the factor "production system", versus only 0.84-1.9% by the factor "microdoses of NPK fertilizer". The observed performances are therefore not due to the fertiliser used but rater to the "Cropping in Plates Under Green Mat" technological package.

Key Words: Cropping system, soil restoration, Fertility, Green Mat, Slash and Burn, Rain-fed Rice

INTRODUCTION

Rice produced in Africa, mainly rain fed, still depends on the rudimentary system known as "shifting cultivation on slash and burn" or simply "Slash and Burn". Peasant practices do exist, however, aimed at shaping a soil unsuitable for cultivation. This is the case in Madagascar, where rice farmers engage in morpho-edaphic transformation of the land (Roose, 2007), cultivation history being more important (Yi *et al,* 2020). Hundreds tons of clay or sand can be applied per hectare to correct the texture, but it is above allmanure which is applied a lot to pass from "Tany Manta" or "raw soil" of the rice fields to "Tany Masaka" or "cooked soil ", which produce more.

"Cropping in plates under green mat" (Green Mat), presented in this article, is an eco-agriculture system, using simultaneous gramino-legumeand herbaceous-shrub fallows, ensuring the maintenance of lush vegetation and of a narrow biogeochemical cycle under agriculture. Sowing is carried out directly on partitioned isohyets (cultivation plates), stabilized with dense hedges of perennial fodder vegetation (green mat). Its most elaborate version is therefore agro-sylvo-pastoral that is prone to reduce net global warming potential (Wang *et al,* 2019; Gong *et al,* 2021).

In addition, the intense production of organic inputs and humus under meadows (green mat) greatly reduces the capacity of the soil to block the available phosphorus conveyed by fertilizers (Mullen, 2005; Kar

*Corresponding author's Email:pyamedieudonne2@gmail.com

et al, 2021). It also leads to desorption of insoluble P linked to metal sesquioxides (Katiyar and Goel, 2004), the complexation of Al^{3+} from the soil solution, therefore the removal of the high toxicity of Ferralsols, and more fixation of nitrogen by symbiotic /assymbiotic germs(Huang *et al,* 2008). This improves the overall chemical properties of the soil.

Furthermore, perennial root structures, through the emission of exudates, organic acids and carbohydrates, of which they are the object (Huang and Wang, 2005; Huang *et al,* 2005; Martinez *et al,* 2008), constitute a unique substrate which shelters and maintains trophic chains, among the widest and most functional. These embrace earthworms, nematodes, bacteria and mycorrhizal fungi (Duffy and Cassells, 2003; Harrison, 2008).

The largest and most active mycorrhizo spheres are thus reported in grassland ecosystems richly endowed with legumes (Da and Deng, 2003; Nautiyal *et al,* 2010), which also are subject of ditch-buried straw layers practice (Yang *et al,* 2020).

Direct seeding under permanent plant or mulch cover (DMC), which is the reflect of innovative Green Mat system, has been widely adopted in the Southern United States of America, Canada and Australia (Aulakh *et al,* 2012) but also in Latin America and Madagascar (Neto *et al,* 2010) as well as in the Mediterranean region where it contributes to a high efficiency of fertilizer and rainwater recovery (Morell *et al,* 2011; Bayat *et al,* 2013).

This, however, by resorting to occasional plowing limited to the outermost layer of the soil (Delaune and Sin, 2012; López-Fando and Pardo, 2012) or burying different biochars in the field (Obia *et al,* 2020; Yang and Lu, 2021).

However, the development of DMCs in tropical peasant agriculture is very timid (Agbede, 2006; Lal, 2007).

The challenge for their adoption in sub-Saharan Africa includes highlighting the pecuniary advantages provided (Tueche *et al,* 2013) and setting up modalities for an efficient incorporation of fallow-green manure and biochar able of controlling cropping weeds (Rockström *et al,* 2009) and soil humidity retention (Shen *et al,* 2021).

These are the most effective Conservation Agriculture management strategies, like the Green Mat system, thereby affecting the nitrogen, phosphorus and potassium balance, which lead to high crop yields. This, by minimizing multifaceted losses, by increasing the mineral recycling index and the efficiency of fertilizer use (Blaise, 2011; Rosolem and Calonego, 2013) and by significantly lowering production costs (Farooq *et al,* 2011). According to Kodzwa *et al.* (2020), Mulching is the most important of the three conservation agriculture principles in increasing crop yield in the short term, under humid and sub humid tropical conditions.The research question, that is the common thread of this study, is therefore formulated as follows:

"Given the unsustainable exploitation and the restrictive occupation of the land under Slash-and-burn, isn't it possible, as a technological design, to capitalize and organize in alveolar spatial structures, all arable surfaces slashed without fire(cropping plates), on the one hand, and all perennial root formations, disposed to provide cover and humus(green mat), on the other, therefore forming an efficient system of eco-agriculture (cropping in Plates under Green Mat)?"Tested in rain-fed rice cultivation, does this system make it possible to increase yields while restoring soil fertility?

MATERIALS AND METHODS

Site Location

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

The test site Is located 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 study undertaken extend from January 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 degradedvegetation groups as a result of hu

man action (Mate, 2001). The hinterland of Kisangani citywas initially made up of evergreen rain forests which constituted its climax.

The experimental site had a previous crop marked by the continuous cultivation of cassava associated with maize. The short-lived fallow areas were covered by *Cynodon dactylon* with sparse patches of *Panicum maximum, Pueraria javanica*and *Calopogonium muconoides*. The lowland area along the stream had *Pennisetum purpureum* cover.

EDAPHO-CLIMATIC CONDITIONS

The soil of Kisangani (Fac. of Sciences, UNIKIS) carrying the Agro-Forest evaluated presented, up Stream, 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. Table 1 below gives the chemical and physico chemical properties of the soil at the start of the experiments.

The city of Kisangani enjoys an equatorial climate of type Af according to the Koppen classification. It is a

Tab. N°1. Characterization of the soil at the end of the preliminary phase (morpho-edaphic optimization), March 2011

Systèmes de production	CO (%)	P available + P organic (mg/kg sol)	$Al^{3+}+H^{+}$ (cmole /kg)	Satu-ration Al^{3+} (%)	Satura-tion en bases %	Bases totales (cmol/kg)	K^{+} cmol e/kg	Na^{+} cmol e / kg	Ca^{2+} cmol e/ kg	Mg^{2+} cmol e/ kg	N (%)	pH au Kcl	pH à H_20	ECE C cmol e/ kg
0-15cm depth soil strate														
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	87.6	12.4	2.18	0.30	0.06	1.34	0.48	0,16	3,5	4.3	17,8
Champs voisins	0,3	25,0	17.6	90.8	09.2	1.77	0.20	0.06	1.13	0.58	0,08	3,5	4.1	19,4
15-30cm depth soil strate														
Tapis vert	1,1	26	17.6	91.6	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	94.3	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	96.0	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 those which do express the aluminum toxicity, the threshold of which is set at 60%. CO = organic carbon; ECEC = Effective cation exchange capacity

constantly hot and humid climate, thus identifying itself with a very high ecological productivity.

The average annual precipitation is around 1800 mm, with average daily temperatures of 24-25°C. However, a considerable increase has been observed over the past 5 years, annual rainfall reaching 2000-2400 mm and the average monthly temperature reaching 27-28°C (Pyame, op cit.). Figure 1 below shows the essential climatic data during the test period.

EXPERIMENTAL APPARATUS

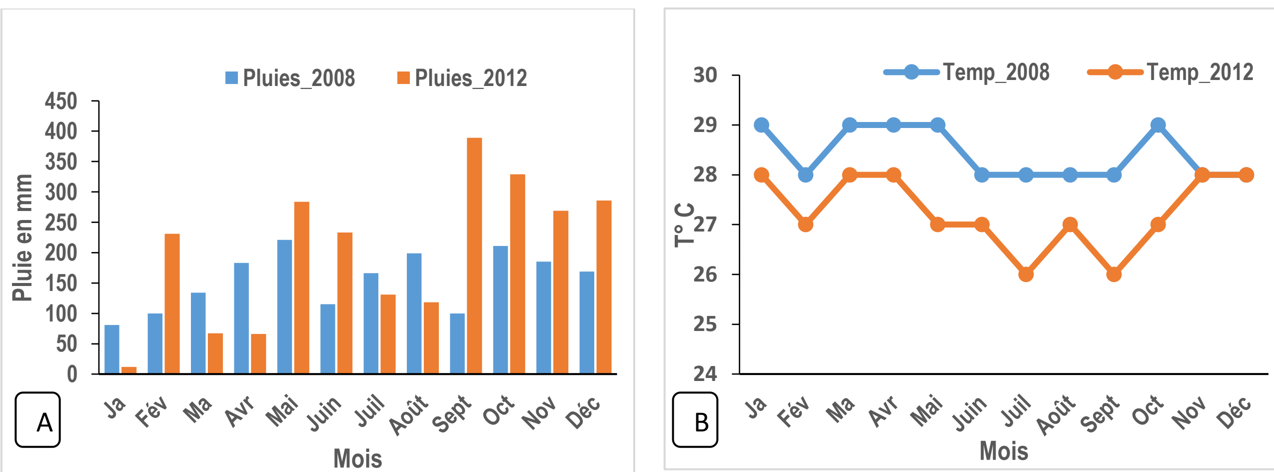

Figure. 1 (A, B). Evolution of monthly average temperatures and rains at the experimental site, between 2008 and 2012 (data from the first and last year of the study). Source: IFA, Department of Plant Science.

The experimental device mounted in this study is given in figure. 2 below.

North

Blocs 1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
T03	T2	T01	T1	T03	T2	T01	T1	T03	T3	T02	T2
T01	T3	T02	T2	T01	T3	T02	T2	T01	T2	T03	T1
T02	T1	T03	T02	T02	T1	T03	T3	T02	T1	T01	T3
T3	T01	T2	T01	T3	T03	T2	T01	T1	T02	T2	T02
T2	T03	T3	T03	T1	T01	T3	T02	T2	T03	T3	T01
T1	T02	T1	T3	T2	T02	T1	T03	T3	T01	T1	T03

West -----> -----> -----> -----> -----> -----> -----> -----> -----> -----> -----> ---->-----> -----> -----> -----> -----> -----> East

Fig. 2. Experimental device A on the trial of rain fed rice cultivation under fallow land and ATV-type green manure against slash-and-burn cultivation. The 3m x 4m plots, elongated in the direction of the slope (8.5%), form blocks perpendicular to it.

Legend -----> = Direction of the slope (water flow)

Definition of treatments:

T01 = 20 t of manure + 00 kg of NPK / ha (BURNS) T1 = 20 t of manure +00 kg of NPK / ha (GREEN MAT)
T02 = 20 t of manure + 50 kg of NPK / ha (BURNS) T2 = 20 t of manure + 50 kg of NPK / ha (GREEN MAT)
T03 = 20 t of manure + 100 kg of NPK / ha (BURNS) T3 = 20 t of manure + 100 kg of NPK / ha (GREEN MAT)

SHORT APPROACH

The procedures for carrying out this study took place in the field, on the one hand, and in the laboratoryof soil analysis, on the other. It all started with the establishment of improved fallow land to restore soil fertility.

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

Fallow fields green manure using *Mucuna-Pennisetum* were established on each of the plots of the device reserved for the practice of the Green Mat system. The first operation was slashing, carried out by clearing-stumping technic at ground level with a machete.

Each plot was crossed by 8 lines of *Pennisetum purpureum*, the latter being established at spacing of 50 x 50cm, thus observing a holy space of 25 cm on either side. A line of *Mucuna pruriens* was then inserted, established in pockets (2 grains) arranged with a hoe every 100 cm.

Maintenance and fertilizing practices under fallow-green manure

A bimonthly cutting regime was observed for *Pennisetum purpureum*, thus making use of cut-clearing technic with a machete, allowing to recycle all the biomass.*Mucuna pruriens* was in free development until the cut-clearing occurred at 6 months. Also, a stake made of *Pennisetum purpureum* was carried out at 1 month for the training of the young plants of Mucuna pruriens.

A first spreading of fertilizers at the rate of 10 t DM of manure /ha, i.e. 12 kg /12m^2 plot, associated with 2/3 of the dose of NPK aligned per treatment was carried out 1 month after planting: this is the technic of "mineral pre-absorption by fallow-green manure" exploited as the first strategy of mineral capitalization.

Subsequently, clearing-stumping-chopping at ground level was carried out 6 months after planting, thus sparing the permanent green mat ensuring the honeycombing of the ground. The exploitation of this impressive biomass after cutting was done by compilation with a layer of manure (10 t DM /ha) followed by spreading on the surface of the soil. Care was therefore taken to integrate the remaining third of the dose of NPK included in the various treatments: this is "transient microbial immobilization of fertilizers", used as a second mineral capitalization strategy in the Green Mat system.

This ultimately produced "the raw mulch-compost fertilizedin situ" which is the backdrop for the "rhizo-bio-organic mat", used as a third strategy of mineral capitalization maintaining a rapid set-up and continual mineral recycling. Root profile samples allowed an evaluation of root production by treatment plot.

Maintenance care and fertilizing practices during the cultivation phase

Light weeding took place on the blocks of the Green Mat cultivation system, while two particularly labor-intensive operations were required in Slash-and-Burn cultivation. A clear cut of the herbaceous green mat was carried out monthly, its biomass being evaluated and integrated into the overall production of biomass (total plant mass) under cropping. The mass of weeds obtained after weeding was recorded as dry matter per plot. The overall productivity of the entire fallow-crop cycles including total rice production was carefully assessed.

On the areas under Slash-and-Burn, the two fractions of the fertilizer dose were applied at once before sowing, associated with the corresponding dose of manure for each plot. Manure under fallow and clearing, in the form of raw mulch-compost, thus integrates the Green mat technological package.

Harvesting, processing and evaluation of yields

The harvest was carried out from block to block, from one system to another and from plot to plot. The bundles of panicles corresponding to the $1m^2$ plot samples were carefully labeled according to the numbering of the plots, weighed on the field, the dry paddy yield (DM) being deduced using an index calculated in the laboratory and the paddy plot yield immediately recorded in the notepad ($kg/12\ m^2$).

The straw harvest and the evaluation of root production were carried out systematically on all the plots, following a rate of progression similar to that of paddy. Calculated indices made it possible to go from root density (g/100cc) to root productivity (t/ha) and to the "soil-root interface" or RLD (cm/cm^3).

Evaluation of texture, root density and soil-root interface (RLD)

The texture was determined using 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 organic matter. The textural triangle of the GEPPA (Group for the Study of Applied Pedology Problems) was used for this purpose.

A wave of analyzes on bulk density and root density on the crop profile, and across the different plots, also followed the same rate of progress as the paddy and straw harvest. The two investigations were coupled. The same 100cc Koppéky cylinder mounted on an auger was thus used, at the same time, 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 to 15 cm and 15 to 20 cm deep. Root extraction and weighing were performed after evaluation of AD.

Chemical analyzes of the soil

The soil samples were taken in December 2010, thus taken for analyzes in Belgium. The current analyzes used are: pH in water and in Kcl, total nitrogen, carbon and organic matter, cation exchange capacity, exchangeable bases (calcium, magnesium, potassium, sodium), total exchangeable acidity, exchangeable aluminum, organic phosphorus and available phosphorus. These analyzes were carried out in the soil laboratory of the University of Ghent according to Pauwels *et al.* (1992).

Enumeration of aerobic microbial organisms.

Samples were taken from the topsoil (0–15cm) of the plots in the experimental area. In the laboratory, an aliquot of 5g was taken per sample and diluted in a flask containing 50g of peptone water. From the stock solution thus formed, therefore representing the 1/10 dilution, decimal dilutions were made up to obtaining 1 / 10,000. The actual count followed the operative path carried out by Kazadi (2012).

Determination of the mycorrhizal potential of the soil

A global operating mode, according to Vierheilig et al. (1998), served as our guide. However, it required many adaptations in terms of concrete operational modalities. At the end of the microscopic observations related to the detection of mycorrhizae, a summary of the results was obtained concerning the pots in which the soybean stalk is declared infected with mycorrhizal fungi or not. They were therefore noted positive (blue coloration of the tissues of the root invaded by structures of the fungus) or negative (all the tissues remaining transparent).
Consulting the microbial abundance probability tables allowed us to estimate the most probable number of propagates per series of 4 decimal dilutions, then per gram of soil sampled.

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 that followed made use of Statgraphics software. The majority of parameters that have been studied in this device have recourse, in turn, to the two-factor ANOVA, for the significance of the differences between treatments, coupled with the Duncan's test for their discrimination.

RESULTS AND DISCUSSION

Crop yield

It emerges from these figures that the cropping in Plates under Green Mat, facing Slash and Burn, leads to a yield 2.6 times higher ($p < 0.0001$) both as regards the yield of paddy, the production overall including crop residues than that of root inputs (5.6 vs. 2.2 t/ha, 44.7 vs. 17.5 tMS/ha and 16.8 vs. 6.5 tMS/ha, respectively).

This last property is of paramount importance because, despite the exports of above-ground biomass, the incorporated and well-distributed roots, in particular on degraded land, constitute both a net supply of nutrients and a reliable agent for the elaboration of root galleries and structural stability for subsequent cultivation.

- The paddy yields obtained at 5.6 versus 2.2 t/ha, confronting the Green Mat system with Slash-and-burn, under the conditions of our trials, are higher than

Figure :3 (A,B,C) below give respectively the yield of paddy rice, the overall yield including crop residues and the yield of root inputs.

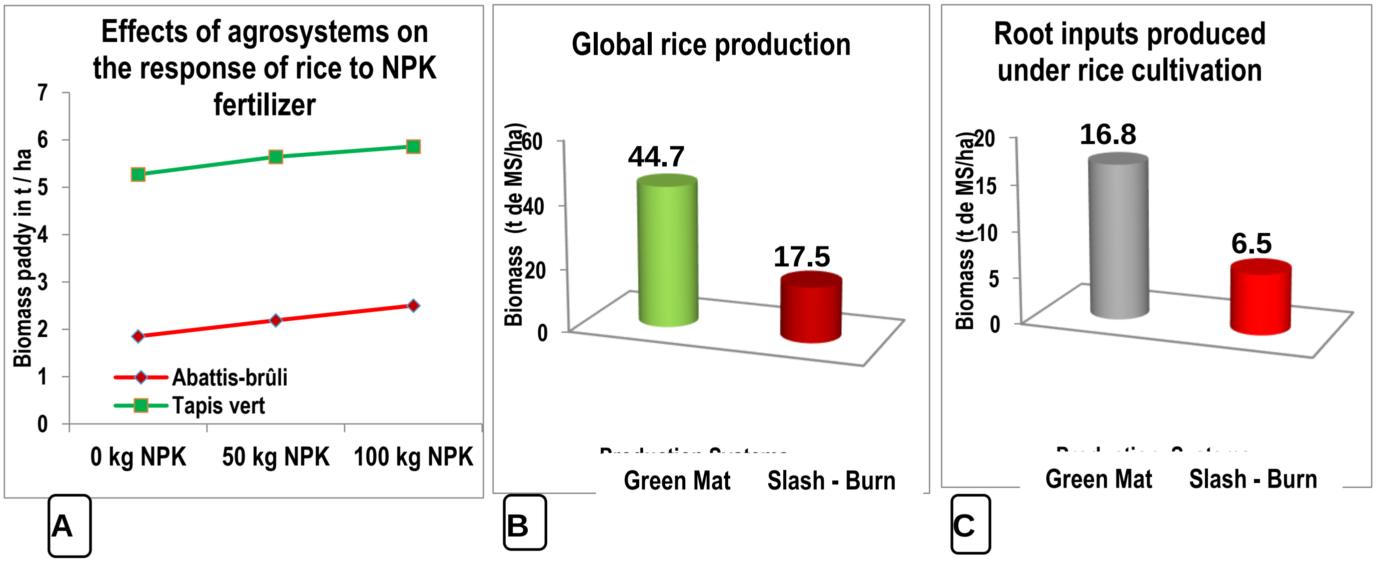

Figure. 3 (A, B, C). Average rice-paddy yield (A), overall production including all residues (B) and production of root inputs (C) in rainfed rice cultivation opposing green mat cropping and slash-and-burn systems. $P_A = 0.0000$, $P_B = 0.0000$; $P_C = 0.0000$.

4.0 versus 1.8 t/ha found by Roose (2007), on depleted land at Madagascar, comparing the DMC system in slash and burn. Séguy *et al.* (2002) report 6 and 5 t for DMC practiced in Brazil and Madagascar. The main asset here is Green Mat management strategies.

- Concerning the implication of the different yield factors, several authors evoke the combined effect of zero tillage with Mulching and mineral fertilization (Mazonchini *et al,* 2011; Melero *et al,* 2011; Smith *et al,* 2011).
- Others underline the high production of organic inputs by the fallow-green manure gramino-legume, the contribution of minimum tillage (Saito *et al,* 2010), the specific effect of *Mucuna pruriens* as a substitute for chemical herbicides, nitrogen fertilization and irrigation (Roscoe and Buurman, 2003) or straw incorporation that significantly altered crop yield, soil organic C and total N in the North China Plain (Liu et al, 2021).
- Mention is made of (1°)"incorporation of manure into treatments", the latter thus releasing NH_4^+ ion which promotes a more spread “mineral supply-demand” synchronization (Chen *et al,* 2007; Bandyopadhyay *et al,* 2010) and (2°) "integrated nutrient management" resulting in high N use efficiency (Mohanty *et al,* 2020).
- Co-incorporation of green manure and rice straw improves rice production and soil health (Zhou *et al,* 2020).

Effects of fallow systems on soil temperature and weeds

The related data is illustrated by Figures 4 below.

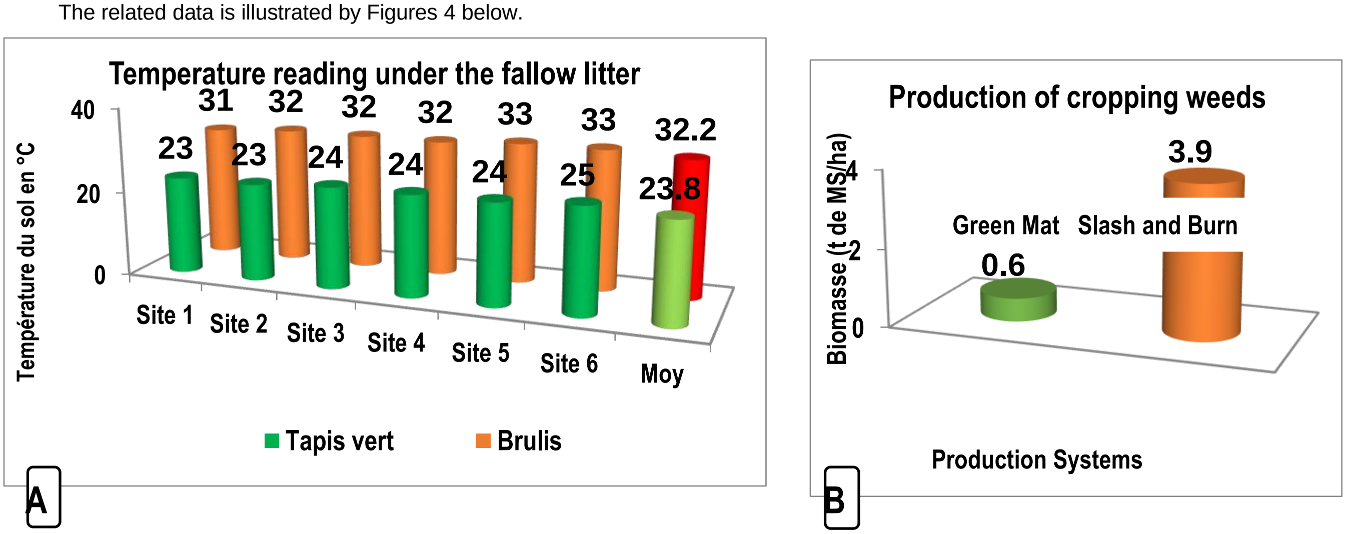

Figure. 4 (A, B). Soil temperature under the fallow litter (A) and production of crop weeds (B) in rainfed rice cultivation between systems of cultivation under green cover and slash-and-burn cultivation. The statistical probability being $P_A = 0.0000$; $P_B = 0.0000$.

Figures 4A and 4B show a significant reduction in the temperature of the surface soil and a very strong repression of cropping weeds (p <0.0001), the average temperature and cropping weeds on all the soils dropping from 32.2°C to 23.8°C and 3.9 tMS/ha to 0.6 tMS/ha, respectively.

This is explained by the "sunscreen effect": the dense gramino-leguminous fallow forms a three-tiered mat (vegetation, litter and root systems) shielding solar rays, tempering the soil atmosphere, and drawing almost all hydro-mineral resources to the detriment of the metabolism of cropping weeds at ground level. Weber (2003) and Baghel *et al* (2020) found a similar effect on soil temperature and cropping weeds respectively.

The repressive effects are attributed either (1) to the establishment, within the framework of precision agriculture, of food plates, cultivation beds or ridges filled with organic inputs (Usman *et al,* 2010; Flores-Delgadillo *et al,* 2011) or (2) to the effect of dense fallow-green manure gramino-legumes (Saito *et al,* 2010), or (3) to the use of conservation agricultural practices, especially those permanently establishing a thick mulch of living plants and crop residues (Gruber *et al,* 2012; Mishra and Singh, 2012; Almoussawi *et al,* 2020), or finally (4) to the synthesis by certain fallow species of bacterial isolates called “weeds-suppressors" (Vakali *et al,* 2011; Soane *et al,* 2012).

Removal of aluminum toxicity by Green Mat and Slash-Burn systems

The related data is illustrated by Figures 5 below.

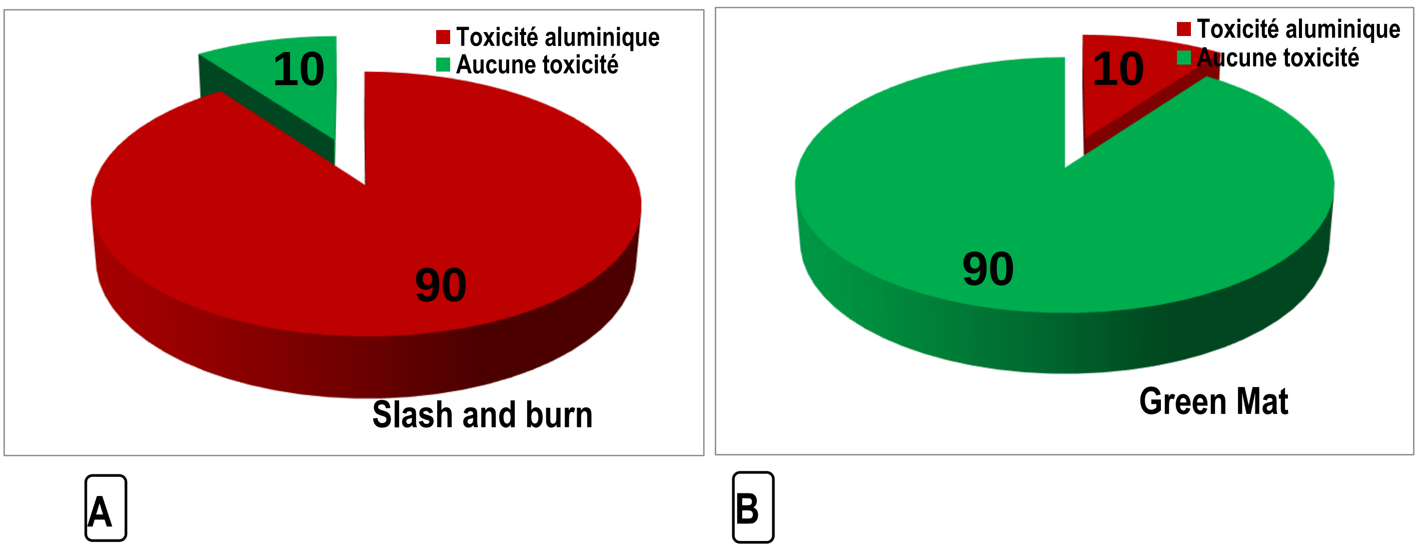

Figure. 5 (A, B): Removal of aluminum toxicity by the system of culture in plates under green carpet (ATV) and the system of culture on slash and burn. The statistical probability related to the interaction between the 2 factors is P = 0.0000.

It emerges from Figure 5 (A, B) above that the lifting of aluminum toxicity, after 2 years of eco-agriculture (integrated mineral-organic fertilization), affected 10% and 90% of the plots, respectively for the slash-and-burn and Green mat (ATV) cultivation. It is therefore more efficient (p <0.0001) in the latter case. This is mainly explained by the complexing action, on free aluminum, of the organic matter and VAM networks (Walder *et al,* 2012; Johnson and Gilbert, 2014; Alvarez *et al,* 2020) developed under the "Green Mat" system versus "Slash and burn".

Overall efficiency of the Cropping in plates under green mat

The related data is illustrated by Figures 6 below

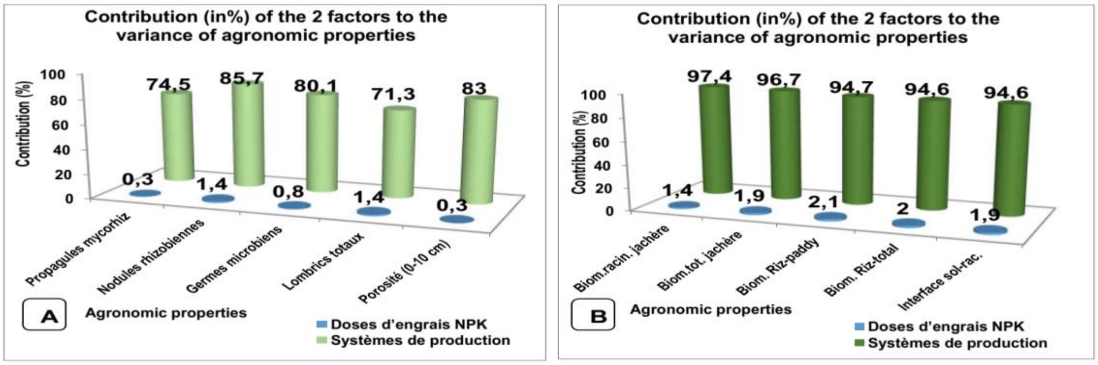

Figure. 6 (A, B). Relative contribution of each of the two factors, namely "production systems" and "increasing doses of NPK fertilizer" to the variance of the various agronomic properties analyzed.

It emerges from fig. 6A that the 5 agronomic properties analyzed display on average a variance controlled at 79% by the production system factor versus only 0.84% by the factor "increasing doses of NPK fertilizer". A similar situation is observed when analyzing the 5 other agronomic properties (figure. 5B), the production system factor largely outweighing the doses of fertilizer with 95.6 versus 1.9% of influence.

Thus, the performances observed in improving treatments for rainfed rice relate, about 90%, to the effects of the "Green Mat" cropping system and its management practices.

For example, the generalized aluminum toxicity under natural cover must be removed beforehand, through appropriate cropping practices (soil-plant interactions), regardless of the quality and level of the associated fertilizer (Fasinmirin and Reichert, 2011)!

We thus note several performance factors of the Green Mat system as a whole:

- hedges of perennial grasses, just like the microbassins and superficial depressions developed during cropping period, play an effective role in reducing water, ions and soil losses under cultivation (Vanden Bygaart *et al,* 2002; Xiao *et al,* 2012; Hubbard *et al,* 2013; Page *et al*, 2019; Zhao *et al,* 2020);
- the integration of mulch from crop residues in mineral fertilization and in the rotation of legumes, greatly contributes to improving nitrogen status and productivity on degraded soils (Álvarez-Mozos *et al,* 2011);
- valorization of fertilizers, in which labile and organic P (Rodrigues *et al,* 2021), ensured by the perennial rhizo-structure sharing the occupation of the land, such as *P. purpureum* (López- Bellido *et al,* 2013);
- an already established mycelium (permanent green mat) has, versus inoculated propagates, a stronger potential for colonization of the roots of plants, even non-mycotrophic species (Püschel and Rydlová, 2007).
- straw recycling in rice paddy can be seen as a trade-off between greenhouse gas emission and soil carbon stock increase (Mi *et al,* 2019 ; Lee *et al,* 2020 ; Singh *et al,* 2020).
- Co-incorporation of green manure and rice straw which improves rice production, soil chemical, biochemical and microbiological properties (Chen *et al,* 2019 ; Li *et al,* 2019 ; Zhou *et al,* 2020)

CONCLUSION

Cropping on plates under green mat is proving to be very interesting as an eco-agricultural technology, in the context of the equatorial and inter-tropical climatic zone. Faced with slash and burn, it clearly shows gigantic performances:

- 2.6 times higher yield ($p < 0.0001$) both for paddy rice, overall production including crop residues and that of root inputs (5.6 versus 2.2 t/ha, 44.7 versus 17.5 tMS/ha and 16.8 versus 6.5 tMS/ha, respectively);
- a significant reduction in the temperature of the surface soil and a very strong repression of cropping weeds ($p < 0.0001$), the average temperature and cropping weeds on all the soils dropping from 32.2°C to 23, 8°C and from 3.9 tMS/ha to 0.6 tMS/ha;
- a lifting of the aluminum toxicity, after 2 years of eco-agriculture (integrated mineral-organic fertilization), affecting 90% of the plots versus only 10% for Slash-and-burn.

The agronomic properties analyzed show on average a variance controlled at 80-95% by the factor "production system", versus only 0.84-1.9% by the factor "increasing doses of NPK fertilizer". The observed performances are therefore due not to the fertiliser used but rater to the "Cropping in Plates under Green Mat" technological package.

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