Quantification of total biomass plant in agriculture conservation practices in Lake Alaotra Madagascar

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1. INTRODUCTION

Conservation agriculture (CA) cropping systems have been reported to reduce runoff and soil erosion (Douzet *et al*., 2010); increase the diversity and abundance of faunal communities, carbon content, and microbial respiration (Razafimbelo *et al*., 2006; Blanchart*et al*., 2007; Rabary*et al*., 2008). Positive effect of CA; systems is in general due to the relatively large amount of biomass returned to soil. Most studies give importance on measuring shoot biomass but rarely roots biomass (Albrecht *et al*., 2002). However, the quantity of belowground biomass can equivalent to aboveground one and it's protected from cattle and fire being located in soil. Therefore, this "hiden" part should carefully evaluate when evaluating the potential of CA cropping system to mitigate CHG emission. The present study focuses on quantification of abovegroundand root biomass of plants used in rotations to help soil carbon budget in the aim of comparing conservation agriculture (CA) and conventional cropping systems (CT).

2. MATERIEL AND METHODE

2.1.Experimental design

This research was carried out in the research station of Centre de Recherche Régional du Moyen Est (CRR-ME), ex CALA in Ambatondrazaka-Ambohitsilaozana, Alaotra Mangoro Region, in Madagascar(17°41'19.87"S, 48°27'34.51"E). The climate is altitude humid tropical. Data recorded for ten years (2002-2012) in Ambohitsilaozana-Ambatondrazaka shows that the average annual precipitation and temperature were respectively 1091 mm and 20.7°C. Soils are classified as ferralsols. Treatments were arranged in a randomised complete block design with four replications. Treatments compared in this study were: CA(no-till and residue retention) versus CT(oxen plough tillage and no residue retention) ; and two types of rotation: a triennial rotation of maize+*Stylosanthes guianensis*//*S. guianensis* //rice and a biennial rotation maize+*Dolichos lablab*//rice.The plots did not receive any fertilizer.

2.2.Biomass sampling

Above and below-ground biomass samples were collected at full flowering in February and March 2013.

Aboveground biomass: full harvest was used for sampling aboveground biomass. For rice and *Stylosanthes guianensis*in pure culture the sampling area was1 m², collected randomly in each plot with three replications. For maize intercropped with *S.guianensis*, and maize intercropped with *D. Lablab*, the sampling area was 3 m^2, with three replications.

Root biomass: the samples (soil coring) were taken from the stainless steel cylinders (10.1cm internal diameter and 40cm height) on the same plots where they had taken the shoot biomass. The samples were collected at two depths: 0-20 and 20-40 cm. For each kind of plot the sample pattern was different, the number of sample per plot were respectively 6, 4, 4, 6 for maize+*S. guianensis, S. guianensis,* rice, maize+*D. lablab.*Calculation of total biomass per hectare was made by extrapolating individual measurement while taking into account relative position of sampling to plant. Two other soil profile per plant/association were dig up to -2 m to estimate the roots biomass above and below -40 cm, the ratio calculated were applied to extrapolate to quantity measured on 0-20 and 20-40 cm to the entire soil profile.

2.3.Evaluation of carbon storage in biomass

Amount of carbon content in biomass were taken from previous measuresmade locally and from literature, they were respectively for aboveground and root biomass: 43and 44 % for *S. Guianensis*; 30 and 30 % for *D. Lablab*; 40 and 40 % for maize (Bolinder*et al*. 1999); and 45 % and 45 % for rice (Agence de l’environnement et de la maîtrise d’énergie Bretagne, 2004).

2.4.Simulation of soil organic matter stock by biomass after model of Hénin-Dupuis (1945)

The Hénin and Dupuis is a monocompartment model used to simulate the evolution of soil organic matter.The Hénin-Dupuis model is (Roussel *et al*., 2001):$\mathbf{Y_t = yo.e^{-K2t} + K_1.x(1-e^{-K2t})/K_2}$; Where: **yt** and $\mathbf{y_0}$ are the quantities of humified organic matter on soil respectively at time **t** and $\mathbf{t_0}$;**x** is annual input of organic matter (Mg): K_1: the isohumic coefficient, depending of the nature of organic inputs; K_2: the coefficient of mineralization, it is assumed to be a characteristic of soil and climatic conditions. K_1 and K_2 vary following the plant and the management system, K_1 is equal to 0.24 for maize; 0.23 for rice;0.4 for *S. Guianensis;* and

0.4 for *D. lablab* (Eldor*et al.*, 1996); K_2 is equal to 0.017 for the CAsystem and 0.046 for the conventional tillage system (Schvartz *et al.*, 2005).

3. RESULT AND DISCUSSION

3.1.Quantities of biomass and carbon in crops and cover crops

Average quantities of biomass and carbon quantity for all treatments studied are summarized in table 1. Generally, intercropped culture provides more biomass than pure ones. Referring back tothe overall results, biomass and carbon biomass in CA system are slightly higher than those in CT system with no significant difference between their values.The main advantage of CA system is the return to soil of plant residue.

Table 1.Quantities of biomass and carbon in crops and cover crops

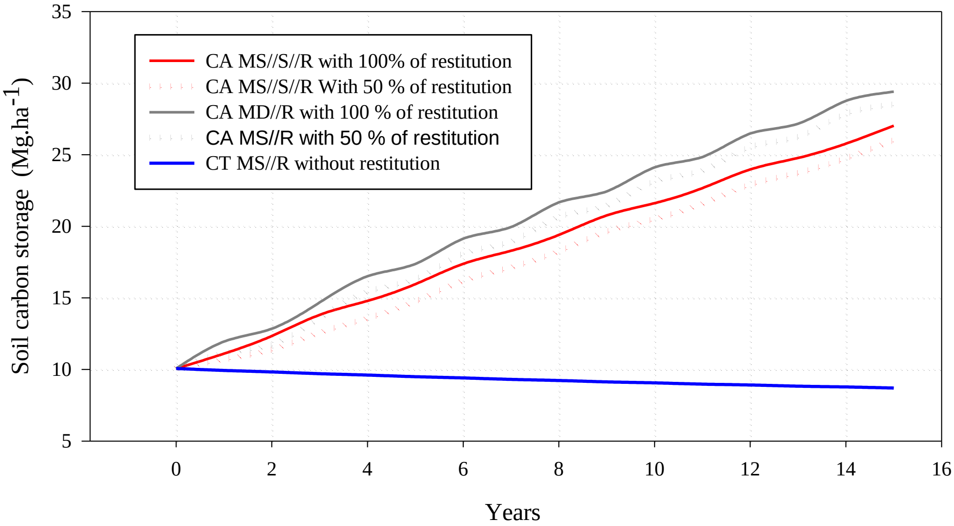
Parameter	Land use	Maize-*S. guianensis*	Maize-D. lablab	*S. guianensis*	Rice
Aboveground biomass ($Mg.ha^{-1}$)	CAsystem	8.4 ±2.2 a	12.3±2.3 b	6.3±1.8 a	6.0±0.8 a
	CT system	7.9±2.5 a	8.9±1.1 a	7.7±1.8 a	6.2±1.5 a
Root Biomass ($Mg.ha^{-1}$)	CAsystem	4.0±1.4 a	2.9±0.9 a	1.8±0.51a	2.1±0.5 a
	CT system	2.9±1.4 a	3.5± 0.3 a	2.6 ±0.8 a	1.7±0.3 a
Shoot carbon ($Mg.C.ha^{-1}$)	CAsystem	3.5	4.3	2.7	2.7
	CT system	3.3	3.1	3.4	2.8
Rootcarbon($Mg.C.ha^{-1}$)	CAsystem	1.7	1.0	0.8	1
	CT system	1.2	1.2	1.1	0.8

Values with the same capital letter are not significantly different among system (CA and CT) at $P < 0.05$ and values with the same small letter indicate no significant.

3.2. Effects of residues returned to the soil over time on accumulated carbon content

Our study reveals that over time, CAsystem increased(for both 100% and 50 % of restitution scenarios) carbon in soil. In contrast, in CT tillage system, it gradually decreasesover time.

Figure 2: Simulation of accumulated soil carbon storage ($Mg.ha^{-1}$) in the soil over time according the model Hénin Dupuis.



4. CONCLUSION

The results presented in this paper indicate thatno significant differences are recorded in biomass between CA and CT systems. The main benefits of CA is the high level of above-ground biomass restitution to the soil and favorable to increase soil carbon over time.

5. REFERENCES

Agence de l'environnement et de la maîtrise d'énergie Bretagne, 2004. Réalisation d'un référentiel technico-économique des unités de méthanisation de produits organiques agricoles et non agricoles à petite échelle en Europe lots 1 et 2. http://www2.ademe.fr/servlet/getBinname=77B34F9F95C1DCCE0EB65FC7D72A64141131453257681.pdfconsulted 30/09/2014.

Albrecht, A., Cadisch, G., Blanchart, E., Sitompul, S.M., Vanlauwe, B., 2002. Below- and aboveground organic inputs, soil C storage and soil structure improvements and consequences for agroecosystems functions. In: Van Noordwijk M., C.G., Ong C. (Ed.), Be.

Blanchart, E., M. Bernoux, X. Sarda, M. Siqueira, C.C. Cerri, M. Piccolo, J.-M.Douzet, E. Scopel, and C. Feller.2007. Effect of Direct Seeding Mulch-Based Systems on Soil Carbon Storage and Macrofauna in Central Brazil.AgriculturaeConspectusScientificus 72(1):81–87p.

Bolinder, M. A., Angers, D. A., Giroux, M., &Laverdi, M. R, 1999. Estimating C inputs retained as soil organic matter from corn (Zea Mays L .). Plant and Soil. 85–91p.

Douzet, J.M., Scopel, B., Muller, B., Rakotoarisoa, J., Albrecht, A., Razafindramanana, N.C., 2010. Effets des systèmes de cultures en semis direct avec couverture végétale sur le ruissellement et l'érosion des cultures pluviales des Hautes-terres de Madagascar. Étude et Gestion des Sols 17 : 131-142.

Eldor A. Paul, Keith H. Paustian, E. T. Elliott, C. Vernon Cole., 1996. Soil Organic Matter in Temperate AgroecosystemsLong Term Experiments in North America. November 26, by CRC Press. 432 Pages.

Rabary, B., Sall, S., Letourmy, P., Husson, O., Ralambofetra, E., Moussa, N., Chotte, J.L., 2008. Effects of living mulches or residue amendments on soil microbial properties in direct seeded cropping systems of Madagascar. AppliedsoilEcology 39: 236-243.

Razafimbelo, T., Albrecht, A., Basile, I., Borschneck, D., Bourgeon, G., Feller, C., Ferrer, H., Michellon, R., Moussa, N., Muller, B., Oliver, R., Razanamparany, C., Seguy, L., Swarc M., 2006. Effet de différents systèmes de culture à couverture végétale sur le stockage du carbone dans un sol argileux des Hautes Terres de Madagascar. Etude et Gestion des sols 13(2): 113-127.

Roussel O., Bourmeau E., Walter Ch., 2001. Évaluation du déficit en matière organique des sols français et des besoins potentiels en amendements organiques. Étude et Gestion des Sols, 8, 65-81p.

Schvartz C., Muller J. C., Decroux J. , 2005. Guide de la fertilisation raisonnée: Grandes cultures et prairies. 115p.