Prospective analysis of economic impact of CA adoption based on rice cropping systems in the Middle West of Madagascar (Vakinankaratra)

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I. Introduction

Conservation agriculture (CA) has been promoted to reduce labor requirements, to improve soil structure, water conservation, yields and eventually smallholder's income through a sustainable rainfed agriculture. Disseminating CA among smallholders in the Middle West area of *Vakinankaratra* in Madagascar has been a component of BVPI-SE/HP[1] development project (funded by French Development Agency/AFD) from 2008 to 2013. Crop rotation is one of the central pillar of CA with zero tillage and mulching. Agronomic study in Madagascar highlights that the use of cereal–legume rotations is most adapted to agro-ecologic conditions in Madagascar (SEGUY Lucien, 2006). BVPI-SE/HP project promoted CA cropping system based on *Stylosanthes guyanensis* because this crop has the capacity to reduce the effect of *Striga asiatica*, a major parasitic plant which reduces significantly cereals production. But CA cropping system based on *Stylosanthes guyanensis* implies a year of improved fallow every 2 years, which is not adapted to small size farm with less than 3 ha that represents 70 % of local farms (Eric Penot et *al*. 2012). Furthermore, managing *Stylosanthes guyanensis* as a cover crop requires a lot of labor which limits adoption (50 to 100 mandays.ha^{-1}). Diversified farm types based on different structural characteristics calls for diversified CA cropping systems for a better potential adoption. A unique CA cropping system is not sufficient to cover the demand. Facing such situation in 2010, research program through SCRiD (Système de Culture et Riziculture Durable) financed by GSDM (Groupement Semis Direct de Madagascar), proposed another CA cropping system such as i) rice//, maize *Cowpea Mucuna and Crotalaria*, ii) rice//maize *Arachis pintoï* and iii) rice //maize *Vigna umbellata*. These CA systems were conducted in research station in order to propose alternatives better adapted to the local context.
The aims of this study are firstly to analyze economic performance of these new CA cropping system compared to that based on *Stylosanthes guyanensis* and conventional system at farm scale, and secondly to identify the potential farmers/adopters of such new CA systems according to each specific farm type.

II. Methodology

The study was carried out in four communes in the Middle West area of *Vakinankaratra* in Madagascar : *Vinany, Ankazomiriotra, Fidirana and Inanantonana*.
A prospective analysis, has been utilized in order to simulate the impact of progressive adoption of CA in a long term (10 years) using the software Olympe: a farm modeling and simulation tool. Every type of farm has been reconstructed according to a regional farmer typology identified in 2012 (characterization survey with a sample of 42 farmers) (Eric Penot et *al*. 2012). The questionnaire covered: the structure of the household (demography, farm size, capital, labor), yields and cost for the calculation of the net margin per activity (including on-farm and off-farm). Criteria of farm typology are farm size with irrigated rice area and *tanety* (upland) area and income diversification through off-farm activities and livestock (Cf.Table1).
Individual interview on 14 farmers complemented by focus group discussion in every commune have been added in 2013 to update data and calibrate the farms model.

[1] Bassins Versants et Périmètres Irriguées Sud Est/Hauts Plateaux

Irrigated Rice field area per capita	*Tanety* area	Income diversification	
		off farm	Livestock
1 : <0,1ha	11 : <3 ha	111 : <1000 Kar	1111 : Without
			1112 : With
		112 : >1000 Kar	1121 : With
	12 : >3ha	121 : <1000 KAr	1211 : Without
			1212 : With
		122 : >1000 KAr	1221 : Without
			1222 : With
2 : >0,1ha	21 : <3ha	211 : <1000 KAr	2111 : Without
			2112 : With
	22 : >3ha	221 : <1000 KAr	2211 : Without
			2212 : With
		222 : >1000 KAr	2221 : With

Table 1 : Structural farm typology in The Middle West of *Vakinankaratra*

Five CA cropping systems have been compared :

- Ta : conventional system as an absolute control
- Ts : CA cropping system based on *Stylosanthes* as a control
- S1 : CA cropping system based on Rice + *Arachis pintoï*// Maize +*Arachis pintoï*
- S2 : CA cropping system based on Rice//maize +*cowpea* + *mucuna* + *crotalaria*
- S3 : CA cropping system based on Maize +*Vigna umbelllata* // Rice

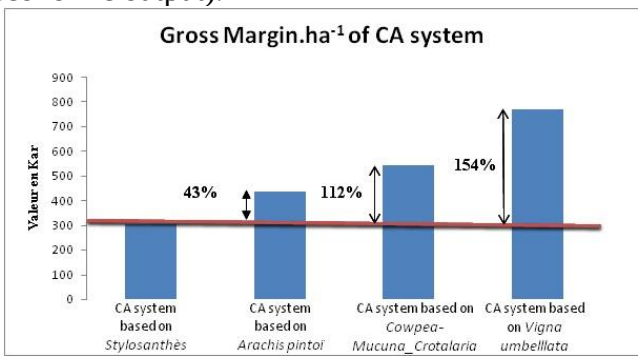
For every CA cropping system, there are two scenarios :

- Scenario with adoption of CA at a level of 50 % of total upland farm area (*tanety)*
- Scenario with adoption of CA at a level of 100% of total upland farm area (*tanety)*

Farm diversified crops, the major crops cultivated in the region are rice, maize, soybean, chickpea, peanuts, cassava. In scenario with adoption of CA at a level of 50% and 100% of upland farm area *(tanety*), conventional system change progressively to CA system. The change of crops and rotations depends on farmer's strategy. For those who priorize food self-sufficiency, they potentially adopt a "rice based strategy" as follows : rice-maize-soybean-chickpea-peanuts-cassava. Those who priorize the crop market value a "cassava based strategy" will be adopted. In this case, change of crop is cassava-chickpea-soybean- peanuts-maize-rice. The economic indicator taken into account is the gross margin per hectare (plot scale) and the agricultural income from upland agriculture (on *tanety)* at farm scale.
Simulation used standard technical itinerary on the basis of a working paper prepared by Raharison Tahina and al. (2012).

III. Results and discussions

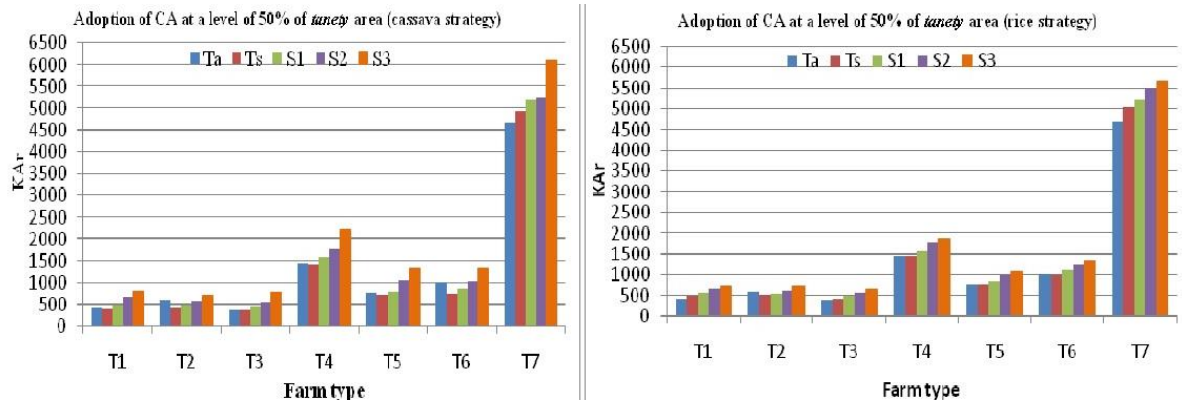
Immediate economic performance depends on the type of chosen cover crop (with or without economic output).



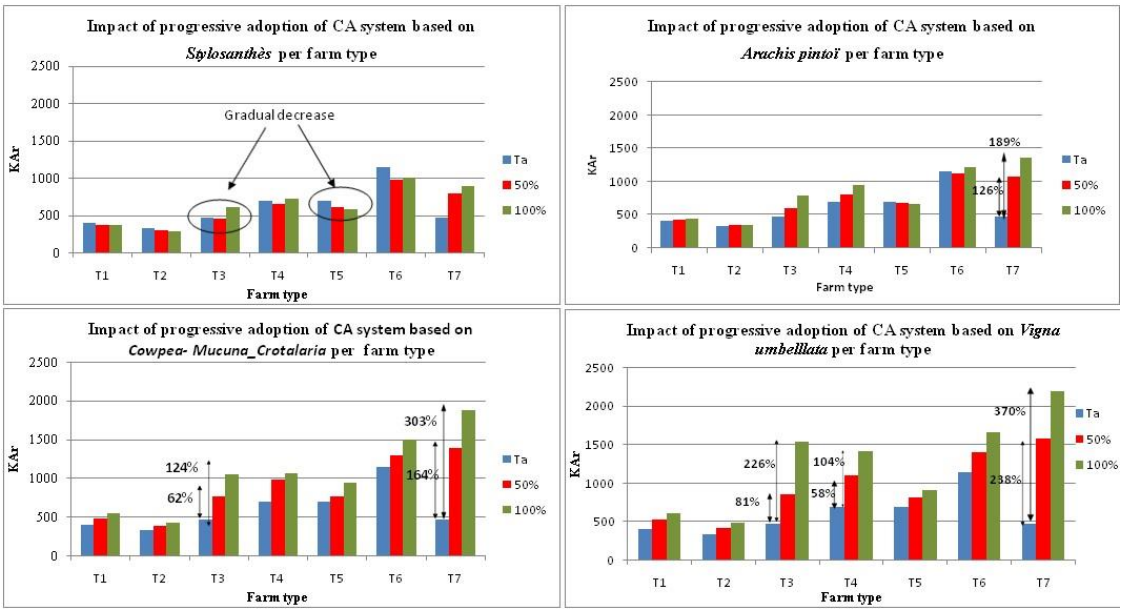
Graph 1: Camparison of gross margin of CA cropping system

Marketable legumes such as *Vigna umbellata* and *Cowpea* enables a complementary income compared to *Stylosanthès* or *Arachis Pintoi* with no direct economic output at plot scale. Meanwhile, CA based on twining legumes are generally low level input system. That's why, *Vigna umbellata* and *Cowpea* are more economically interesting at plot and farm scale compared to conventional system (Cf. Graph 1 and 3) however their role as a plant service is not as good as *Stylosanthès or Arachis pintoï*. Scenario with adoption of each CA cropping system on the entire *tanety* area is more interesting than on the half. But, it seems inconceivable for farmer. Crop diversification is an integral part of their strategy and they do prefer to produce upland rice, maize, cassava, peanut with no pressure on crop rotation over the years to ensure food security. However, these two systems, *Vigna umbellata* and *Cowpea* require as well more phytosanitary products that is highlighted by focus group discussion.

Cassava strategy is more interesting compared to rice strategy only for CA cropping system based on *Vigna umbellata* especially for farm type T7 (Cf. Graph 2).
Impact of CA adoption is different from on farm type to another (De Charentenay, 2011). Farm type T7, a large farm with necessary financial resource, can afford a long fallow and can use more chemical fertilizers. These farm types can take maximum advantage to CA compared to conventional system and can last CA over time, whatever the CA cropping system. However, such farmer do prefer to invest in other income generating activities less risky such as collecting and trade activities, processing agricultural products…as a consequence of low price of the agricultural products and climate hazards (Cf. Graph 3).



Graph 2: Comparison of on farm income of CA cropping (half of SAU of *tanety* area) and conventional system per farm type



Graph 3 : Comparison of on farm income of CA cropping system (half and entire of SAU of *tanety* area) and conventional system per farm type

Graph 3 shows also that farm type T3, T4 and T6 have a real potential to adopt CA cropping system based on *Vigna umbellata* especially and slightly less for *Cowpea based CA*. Similar results is gotten by SOREZE (2010) which indicate that CA adoption allows income increase for mid-size farm.

Agricultural production, characterized by semi-intensive, low input, without fallow, practiced by small farm in particular T1, T2 and T5, which dominate the most farm type in the Middle West of Vakinankaratra (Eric Penot and al. 2012), is considered as a non-sustainable practice. In this case, CA system might be an alternative to limit soil degradation and maintain an acceptable yield and therefore income.

Especially for *mucuna*, seeds can be used in pig feeding. CA systems based on Cowpea *Mucuna* highlight crop-livestock integration. Indirect income generated by CA system on livestock were not valuated in this study.

IV. Conclusion

Research has provided three new CA cropping system: i) rice// maize *cowpea mucuna* and *crotalaria*, ii) rice//maize *Arachis pintoï*, and iii) rice //maize *Vigna umbellata* in addition to the original and unique CA cropping system based on *Stylosanthes* promoted since 2003 in the Middle west of *Vakinankaratra*.

Prospective analysis in a long term (10 years) revealed that the three proposed CA cropping systems are potentially economically interesting compared to CA cropping system based on *Stylosanthes.* Therefore, the income gap among CA cropping system varies from a farmer to another and from a system to another.

Not all Farmers in the Middle West of *Vakinankaratra* seem to be predisposed to adopt and maintain CA over time. Financial and land resource create distinctions. Farm type 7 is less interested by agriculture in general and do prefer investing in non-farm activities. Farm type 3, 4 and 6 can potentially adopt new CA system based on *Vigna umbellate* which is economically interesting at plot and farm scale and is appropriate to small size farm with less than 3 ha.

This study allowed us to measure separately effect of each CA cropping system at farm scale. To improve analysis prospective, which can be used for extension, further research on farmer strategies (cassava and rice strategy, crop diversification, impact of livestock…) need to be implemented.

V. Références bibliographiques

1. De Charentenay Jérémie. (2011). Evaluation socio-économique de l'impact de l'adoption des techniques de semis direct sur couvert végétale sur le revenu des agriculteurs dans le Moyen Ouest de Madagascar (Ankazomiriotra), Rapport Projet RIME-PAMPA, AFD, 24p. CIRAD.
2. RAHARISON Tahina, PENOT Eric et Equipe FAFIALA Ankazomiriotra. (2012). Les itinéraires techniques standards des systèmes diffusés dans le Moyen Ouest pour la region Vakinankaratra – zones fafiala, 36p.
3. RAZAFIMAHATRATRA Mamy Hanitriniaina, ERIC Penot, Marie QUEINNEC. (2012). Typologie des exploitations agricoles dans le Moyen Ouest de Vakinankaratra, Document de travail SCRID/SPAD.
4. SEGUY Lucien (2006). Le semis direct sur couverture végétale permanente (SCV): Une solution alternative aux systèmes de culture conventionnels dans les pays du Sud, Rapport de mission.
5. SOREZE Julie, ERIC Penot. (2010). Evaluation de l'impact des systèmes de semis direct sous couvert végétal (SCV) à l'échelle de l'exploitation agricole dans le Moyen Ouest de Vakinankaratra, Madagascar, document de travail collection AFD BVPI-SE/HP. .