RICE SECTOR SUPPORT PROJECT

(RSSP)

Republic of Ghana

# Ministry of Food and Agriculture


**Support mission to the R&D program for a transfer and adaptation**

**to the Northern regions of Ghana**

**of Direct Seeding Mulch based Cropping systems**

*28/09 – 12/10/2014*

Mission Report on R&D component of the Rice Sector Support Project
Savanna Agricultural Research Institute

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Equipe CSIA

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## Schedule of the mission

Sunday 28th September (out of scope of the RSSP mission)

Pm train Nîmes - Paris
night in Paris

Monday 29th (out of scope of the RSSP mission)

am Participation to the workshop Geocoton

pm Prospective exchanges on collaboration between AIDA \ CSIA and Malteurop in Ethiopia
night in Paris

Tuesday 30th

All day flights Paris – Amsterdam – Accra (arrival 8:00 pm)
night in Accra

Wednesday 1st October

am Flight to Tamale (arrival 7:15 am) – exchange and mission planning

pm rapid visit of collections and meeting with Dr W. Dogbe

Thursday 2nd

am 1st visit of Nyangpala Station's experimental system

pm assist Brazilian machinery assembling

Friday 3rd

am Visit Community's demonstration plots on Upland and Midland-up in Zugu

pm Visit Community's demonstration plots on Upland and Midland-up in Djantong
Meeting PC unit of RSSP

Saturday 4th (Aïd El Kébir)

All day Reporting

Sunday 5th (Aïd El Kébir)

All day Reporting

Monday 6th

am Visit Community's demonstration plots on Upland and Midland-up in Nwodua

pm 2nd visit of Nyangpala Station's experimental system

Tuesday 7th

am 2nd visit of rice collection and rice breeding program (selection and multiplication)

pm preparation of fields days

Wednesday 8th

all day Crossed visits of some members of the 3 villages' committees in Zugu and Nwodua ; participatory debriefing and exchanges on finishing cropping season

Thursday 9th

all day DMC fields days at Nyangpala station (3 communities + representatives of Development projects and private sector)

Friday 10th

am Debriefing and prospective on the 2015's program with the all Rice department team engaged in DMC activities

pm Rapid meeting with SARI's director
Debriefing with PC Unit in Tamale

Saturday 11th

am Tamale – Accra

pm reporting
Accra - Amsterdam

Sunday 12th

am Amsterdam – Paris

pm Paris - Nîmes

**Met persons**

SARI

| | |
|---|---|
| Dr S.K. NUTSUGAH | Director of SARI |
| Dr Wilson DOGBE | Director of the Rice section |
| Michael MAWUNYA | Scientist in charge of DMC experimentation (Station) |
| Elsie SARKODEE ADDO | Scientist in charge of DMC experimentation (Communities) |
| Sampson ALHASSAN | Technician on DMC experimentation (Station) |
| Dela KUADUGAH SAVIOUR | Technician on DMC experimentation (communities) |
| Dana XXXXXXX | Technician in charge of rice collection and multiplication |
| Anne PERINELLE | RSSP-SARI Junior expert – support in DMC R&D program |

Ministry of Agriculture

| | |
|---|---|
| Samuah XXXX | Mechanic Engineer |

PCU of the RSSP

| | | |
|---|---|---|
| Richard TWUMASI ANKRA | Director | |
| François PERROT | Technical Assistant | |
| Elise FICHET | VI | fichet.elise@gmail.com |
| Lucien ROSSIGNOL | Consultant SOFRECO – Agricultural Economist | |

AFD

| | |
|---|---|
| Xavier MURON | Chargé de mission – Accra agency (not contacted) |
| Virginie BARTHES | Chef de Projet – Paris (not contacted) |

USAID

| | |
|---|---|
| Brian KIGER | Deputy Chief of Party of IFDC bkiger@ifdc.org |

Private and NGO

| | |
|---|---|
| Claude D. CONVISSER | President and Gal Counsel POP Diesel (Jatropha project) |
| Xxxx YYYYY | IWAD project (Wienco) |
| David PEREIRA ESPASANDIN | Ag. Project Manager AgDevCo despasandin@agdevco.com |

**Abbreviations and Acronyms**

| | |
|---|---|
| AFD | Agence Française de Développement |
| a.i. | active ingredient |
| AÏDA | Agroécologie et Intensification Durable des cultures Annuelles CIRAD-Persyst's Research Unit |
| Brach | *Brachiaria ruziziensis* |
| c.c. | cover crop |
| CIRAD | Centre de Coopération International en Recherche Agronomique pour le Développement |
| Crot | *Crotalaria sp.* (*C. juncea*, *C. retusa*, *C. spectabilis, …*) |
| e.p. | elementary plot |
| IFAD | International Fund for Agriculture Development |
| IRAD | Institut de Recherche Agronomique pour le Développement (Cameroon) |
| IWAD® | Integrated Water and Agricultural Department (Wienco® Ghana Ltd.) |
| NRGP | Northern Region Growth Project (IFAD) |
| MoFA | Ministry of Food and Agriculture |
| RSSP | Rice Sector Support Project |
| SADA | Savanna Accelerated Development Authority |
| SARI | Savanna Agricultural Research Institute |
| SOC | Soil Organic Carbon |
| Stylo | *Stylosanthes guianensis* |
| TSP | Triple Super Phosphate |

Sincere thanks to SARI's and PCU teams for the good organization of the mission and their warm welcome all along the stay. Special thanks to farmers of the 3 pilot communities for their time and active engagement in exchanges on technique design and access.

## Introduction

### Background

This support mission to the RSSP R&D component on DMC adaptation-transfer is part of the backstopping plan established during the mission of Oumarou Balarabé and Stéphane Boulakia in October 2013. It came after the mission of

- Abakar Madam Diogo (April 2014) ; focus on the implementation of the part of the R&D methodology conducted with and for the communities (finalization of the rapid diagnosis, establishment of village committee, discussion and programming of fields activities, programming of information, exchange and training …)
- Stephane Boulakia (June-July 2014) ; support to on-farm and on-station experimentation system implementation

### Objectives

The principal aims of the mission planned at the end of the rainy season, prior to crops' harvest consist in

- Take stock of the crops development and systems management across the experimental system managed by SARI \ Rice department
- Draw practical advices for the improvement of DMC based systems management and their adaptation to local bio-physic conditions in initial phase
- Contribute to exchange and debriefing of the finishing cropping season with the 3 farmers' committees in the 3 pilot communities through crossed fields visits in villages and opened field day in Nyangpala station
- Introduction to the functioning of small and medium scale ag. equipment financed by RSSP that just arrived at Nyangpala station from Brazil
- Prospective on the programme evolution for the 2015 cropping season following the decision taken to prolong some activities of the RSSP (including R&D component) to mid-2016 and possibilities of relay supports through new partnerships and supports

This mission being mostly oriented on practical support to SARI's fields operation, the present report will be short and mostly consists in

(i) a synthetic reminder on main observations and comments made on the cropping systems management during working visits with SARI's staff,

(ii) proposal for the on-station experimentation and on-community based tests evolution in 2015,

(iii) advices in the initiation and support to on-farm pilot extension from 2015 and onward,

(iv) a draft schedule proposal for CIRAD researcher and Sodecoton engineers supports in 2015-2016, mobilizing remainder on current contract and complementary fund planned by PCU for extension ; to be discussed and amended by SARI and PCU prior submission to the next steering committee of the RSSP.

## I- Comments and recommendations on R&D programme implementation

This chapter proposes

(i) a rapid return on …
(ii) comments on management's improvement and protocols' adjustments for the experimentations and fields' tests implemented at Nyangpala station and on the 3 selected communities in 2015
(iii) a reminder on 2 emergencies : seeds orders + production and some equipment's to be locally built
(iv) a sketch of program evolution and CIRAD-Sodecoton support planning in 2015 – 16.

### I-1 Nyangpala station experimentation

*Preliminary remarks and reminders (cf. previous missions report for details)*

Some recommendations have been ignored or not plainly taken into account, leading to some improper crops and experimentation management:

***Erosion gullies must be totally controlled on the experimental site*** (demonstration):

- implementation of cover-crop on the bund (e.g. *Brachiaria humidicola* in Midland and *B. ruziziensis* in Lowland) – cf. **Photo 17.**
- transitory small "dams" with wood sticks and cut grasses to slow down water flows in gullies between blocks and allow development of cover crops to be sown or set up by cuttings

with arrival of new funds source, planning and implementation of a global anti-erosive plan through complete station land development and Conservation Agriculture adoption : hedges, anti-fire walls, permanent contour bunds fixed by cover (high values timber trees, bushes –fire woods, fodder-, perennial cover-fodder crops, … - cf Raunet, Seguy report, 1993). –cf. below, proposals for coming support missions.

**Experimentation design must be fixed**

All elementary plots (except for plow based system) are permanently delimited by concrete stones (size e.g. 60 cm high, 50 cm buried in soil, 10 cm square section).

**Seeds treatment and quality control**

In DMC … like for any crops sowing, germination power (rate and vigor) control prior to all sowing is essential to adjust sowing rate and avoid insufficient crop's initial stand

*I-1-1 Upland experimentation*

*Principle observation and comments*

Despite recommendations made in October 2013 (cf. appendix 1 on land preparation), soil hasn't been decompacted by chiseling prior to experiment and crops implementation; thus, all "DMC" based treatment have been set on the worse conditions, on compacted profile with bare soil surface (no or few crops residues, no cover crop). These severe constrains have, by contrast, provided marked advantages to the plow based management

which presents better maize development. For the same reason, differences between fertilizer's levels are more pronounced on "Plow" than on "DMC", where crops are limited by physical parameters in first instance and are thus poorly responding to any extra fertilizers inputs.

This general soil compaction is confirmed by the presence of Ludwigia sp. in the weeds which signed severely hydromorphic conditions; weeds pressures are important and might remain so as long as no cover is obtained.

Cover crops have been poorly implemented in association as well as in pure stand for a conjunction of reason (late arrival the imported seeds -# 40 DAS- that leads to sow the Stylosanthes in already well developped crops, medium rate of germination -#50%- that hasn't been checked prior sowing, and –possibly- a bit too deep sowing in hydromorphic / waterlogged conditions.

As other minor comments, it can be noted

- the rice variety Nerica 14 is tall which reduced the chance of good settlement of the associated Stylosanthes guinanesis when sown at 40 DAS ;
- poor density of Soybean that should have lead to rapid complement sowing ; the cycle of the chosen variety was too long, considering the late sowing date (early July) ; at least 2 varieties, presenting short (95-100 days) and medium (115-120 days) should be selected and multiply every year, in order to be able to chose the most adapted one according to the sowing date (medium cycle, to be sown before the 20-25$^{th}$ of June; short cycle after); relay crops and cover crops being sown at the beginning of the defoliation (sorghum + Stylo.) i.e. # 20-25 days before harvest.
- For the association between maize and *vigna unguiculata* (cowpea), test the 2 possible options:
    - Maize + cowpea lc ($\geq$ 120 days) with cowpea sown early in maize inter-row (# 15-20 DAS) → favor to associated biomass production
    - Maize + cowpea sc (< 85 days) with cowpea sown late, # 20 days before harvest → favor to secondary grain production

*I-1-2 Upper Midland*

The experimentation aims at comparing different mode of cover crops setting in association with the rice crops: different cover crops or cover crops association sown in line or by broadcast sowing at the beginning of the rice cycle (25-30 DAS) … but no cover crop have been sown in association with rice.

Rice development is correct to good ; DMC is similar or slightly better than plow based system despite the quasi absence of cover crops at sowing. Physical conditions (compaction and presence of hard pan) are less limiting for the rice growth in the midland and lowland agro-ecosystems

Cover crops and cover crops association sown in pure, in preparation biannual rotation (Rice + cc // cc) are moderately well implemented.

The choice of the rice varieties must also be reconsidered :

- Nabogo is not adapted to DMC practices ; too tall development combined with a long cycle lead to a complete shading of the inter-row space ; the long cycle (130 days) also limits the possibility to implement the cover crop after the rice harvest, especially in midland and in case, like this year, of late rice sowing

- NERICA var. chosen for the system with short cycle rice are not the best adapted variety type for midland and lowland and must be changed … (cf. infra).

*I-1-3 lower Midland*

*Test on cc implementation*

- No cc have been sown in association with the rice …
- The part to be sown with cc, Sesbania sp. + Stylosanthes g. has been sown with Sesbania sp. only ; it presented a good development in October 2014 but leaves were strongly attacked by a larvae of a small coleopteran.
- DMC rice is also similar or slightly better than plow based system (to be confirmed after harvest)

*Rice Collection*

Only "local" varieties were tested in comparison with the reference Nabogo … among them the var. Digang seems to be more adapted for DMC based systems (shorter size and cycle). It is thus recommended to adopt Digang in experimentation for upper and lower midland in 2015.

In the meantime, varieties assessment must be enlarged to the remaining Sebota varieties that have been introduced since 2012 and up to now just maintained in small scale collection (cf. infra).

*"Real scale" demonstration*

This demonstration is based on a simple bi-annual rotation between Rice and a mix cover crops sp. cultivation, implemented on 2 plots of about 3 000 m². Due to lack of mechanical equipment (not yet arrived at sowing time), the rice had to be sown manually.

The rice plot has been sown on "real" cover (mixture of sp. dominated by Stylosanthes) of more than 6-7 t/ha of dry matter; it can be considered that this demonstration is the sole example of true DMC management at Nyangpala station in this cropping season. Nabogo var. presented a good and regular development (cf. up left picture on cover page of the present report) with an expected production of about 4 t/ha, close to its potential; the plot is very clean with only one post application of herbicide and one rapid weeding (# 20 labour.day/ha). No attempt of cover crop sowing in association.

The cover crop plot present a mixture of species including Centrosema pascuorum and a very promising and spontaneous species, most likely *Indigofera hirsuta* (**Photo 15.**). A maximum amount of *I. hirsuta* should be harvested (the manual collect is easy compared to many other legumes sp.). The development of the cover should be sufficient to allow a test of mechanical sowing (using the 2 rows Fitarelli planter) in good conditions during next cropping season.

**I-2 In-communities fields works**

*reminders*

The in-community program has been limited to the sole collective demonstration sites set on both upland and midland positions

Sites are implemented by farmers in coordination with the committee and research; each of them gathers on 2-3 000 m² (cf **Table 3**):

- 2 DMC systems compared to NT (No Till on crops residues without cover crops) and dominant farmers' practices
- 3 cover and/or fodder crops and cover – grains production species

**Table 3**: Contains of the demonstration sites conducted in communities

| | | | |
|---|---|---|---|
| UPLAND | CC1 *Brachiaria ruziziensis* | MIDLAND | CC1 *Stylosanthes guianensis* |
| | CC2 *Crotalaria retusa* | | CC2 Sorghum |
| | CC3 Cowpea | | CC3 *Brachiaria ruziziensis* |
| | DMC1 Maize + Brachiaria | | DMC1 Rice + Stylosanthes |
| | DMC2 Maize + Crotalaria | | DMC2 Maize + rice + Stylosanthes |
| | Direct seeding Maize | | Direct seeding Maize + rice |
| | Farmer practices | | Farmer practices |

*I-2-1 Comments and observation for the 3 communities*

All sites have been properly managed by communities and monitored by research; the degree of commitment of the committee's members is –of course- depending on the perception of the short term potential interest of the proposed direction of innovation; in this regards, the involvement of Jantong's committee has been more limited than the ones of Nwodua and Zugu, due to important land reserve and possibility to maintain a farming system based on an extensive land and labour management.

*Labour organization in communities' demonstration / experimentation plots*

All communities have mentioned their interest in the experimentation but also obvious difficulties to organize correctly a collective work on the demonstration sites; in some cases (notably in Jantong), SARI's team has been obliged to complete and even replace farmers to achieve urgent tasks. To solve this problem, communities have proposed to adopt an individual management (often by the land owner) of the plot (or a management by a small sub-group of committee's members); in these evolutions that could be different between communities, research must pay attention to several points:

- maintain an active commitment of the committee's members in the plots supervision which will need to set a clear distinction between the functions of the committee (exchange and feed-back with SARI's team, decision making on experimentation evolution, support for some tasks like fencing when needed, communication with the all committee … which will need regular visits of the plots) and those of the person(s) in charge of sites management (crops implementation, exchanges on technical management with research team and committee members); this share of responsibilities must be clearly set before the beginning of the next cropping season.

- make a clear distinction between the "collective" demonstration sites and the coming individual plots implemented by farmers interested by testing DMC based management on their farm; those farmers will be part of a pilot extension network and will exchange first with SARI's team; they will share their experiences during regular working exchanges organized by research and communicate externally at the occasion of fields days (once or twice a year).

*Upland sites*

Maize growth and production (Maize crops were just harvested at the mission time and yields results weren't available) are similar in demo plot and in the neighboring farmers plots (and systematically better than the "farmers' practices" treatment which have been poorly managed due to the above mentioned work organization); based on visual observation, maize production in the different cropping systems can be ordered as follow (cf. **Photo 15** and **16**):

Maize + *C. spectabilis* > Maize ≥ Maize + *B. ruziziensis*

Good implementation and growth of the pure cover crops (except one plot of Brach. in Zugu) and the cowpea (# 800 to 1 000 kg/ha with 2-3 insecticides treatments against bugs) in future, test collection of varieties -possibly coming from farmers- for different cycle's duration and purpose orientation grain *vs* biomass).

*N.B.* *Striga sp.* is a major pest, as it has been mentioned by farmers (addressed by rotations with groundnut and cowpea), but none of the 3 demonstration sites present important pressure; if the importance of Striga is confirmed, it could be interested to test and demonstrate DMC interest to solve this problem, by proposing implementation of farmers' plot under severe pressure (test Maize + C. spectabilis or Cowpea in 1st year).

*Midland sites*

In this situation, Maize crops (in association with rice) have been sown far too late; it has then after encountered soon waterlogged conditions and also induced a delayed sowing of the rice (planned # 15 DAS of the maize).

Rice sown in association with Stylosanthes g. presents a development similar to neighboring farmers' plots and to "farmers' practices" treatment; associated Stylo is present even if on too low density.

Stylosanthes g. and Brachiaria r. behave properly in this midland situation and confirmed their capacity to face waterlogged conditions. It will be interested to follow-up the behavior of these two species along the dry season.

The Sorghum crops were also nice in the 3 communities (yield # 2 000 – 2 500 kg/ha) but the chosen short cycle variety may not behave so well in case of earlier sowing (May-1st half of June); for these dates, chose the "traditional" farmers variety (*S. guineensis* -?-) which also offers a greater biomass production. Sorghum in association with Stylosanthes could integrate bi-annual rotation with rice in this landscape unit. It could also be associated to Brachiaria sp. to develop surface devoted, later on, to pasture and/or fodder production.

*I-2-2 Nwodua*

- Active committee with several farmers willing to adopt element of DMC based systems in 2015.
- Declared possibility of individual management of the plots during rainy and dry season, in both upland and lowland situations; fencing of individual plots being considered as an option by farmers interested in DMC adoption.
- Close to the upland demonstration site, existence of a fallow covered by a mixture of legumes and grass weeds (**Photo 14.**) that could be directly cropped under DMC by the land owner with the technical support of the SARI's team (pilot extension network).

*I-2-3 Zugu*

- Like in Nwodua, active committee with several farmers willing to adopt element of DMC based systems in 2015, mostly for upland.
- The midland area chosen for the demonstration site isn't intensively cropped (less than 20% of the surface, no rice but short cycle crops in early wet season like cowpea and watermelon and long cycle sorghum – *S. guineensis*) and seems to be considered as a collective pasture land in rainy season (based on farmers' declarations but few animals were seen during the 2 visits made in this mission). The suggestion of developing improved pasture (*Brachiaria sp.* or a mixture of *Brachiaria sp.* + legumes –e.g. *Macroptilium atropurpureum*) has been considered as difficult to arrange.

*I-2-4 Jantong*

- More "distant interest" of the committee for the research proposals which appear, at this stage without introduction of mechanization as too labour intensive compared to dominant practices.
- With the lowest anthropic pressure, parts of the large fallow surface in upland are covered by an association between *Imperata cylindrica* and a legumes sp. (**Photo 12** and **13.**). This type of cover offers an easy and direct "entry point" into DMC based management (Imperata indicating very favorable soil structure). For 2015, It is thus suggested to discuss and propose to the committee to identify few farmers owning such a kind of fallows and test with them (pilot extension network) a direct conversion into DMC systems for Maize production, based on mechanization (rolling and sowing).

## II- Evolution of the DMC R&D program in 2015

### II-1 Planting material collection and multiplication

*Reminder*

Maintaining the collections that have been introduced from Cameroun, Brazil and Cambodia and initiating a significant seeds production for the most interesting species and varieties must be a top priority for the R&D component in order to allow the progressive development of the current and future programs (stay able to sustain initial farmers plots extension without being limited by any lack of seeds) … and extent capacities to interact with other R&D and D programs willing to integrate Conservation Agriculture and fodder extension in their "portfolio" of activities (cf. Advance program funded by USAID).

Conduct a continuous plants collections development and assessment is a central R&D action to allow DMC cropping systems progression (performance of systems, "emergence" of new systems). This work concerns both cover and/or fodder crops species (and var.) as well as food crops (DMC for cotton production could be developed later, according market / project attractiveness).

*II-1-1 Cover - fodder crops*

A priority focus must be given on the following species:

- *Stylosanthes guianensis*
- *Brachiaria ruziziensis*

- *Centrosema pascuorum* (due to hand harvest difficulties, some surfaces could be sown with 0,8 m interrow in order to set a plastic mulch between lines at 45 DAS ; plant are cut and removed after seeds production ; seeds are collected on the plastic)
- *Sesbania sp.* (multiplication and collect)
- *Indigofera hirsuata* in the lowland of Nyangpala station (**Photo 15.** - easy hand harvest)

For this purpose, some significant surfaces of Stylosanthes g. have been sown, but unfortunately too late to produce seeds in the year (*a priori* before mid-June) in the Nyangpala station's fields.

Practical recommendations have been done to farmers for Brachiaria hand-harvest in communities' demonstration sites training (first flowers appearing at the time of mission).

*For upland*

- Fodder crops
  - legumes sp.
    - ***Stylosanthes guianensis*** (cv. CIAT 184, Nina, …), *S. hamata*, *Macroptilium atropurpureum*, ***Centrosema pascuorum*** (var. Cavalcade, Bundey), *Chamaecrista rotundifolia* (seen on the side of Tamale road in Nyangpala station), Calopogonium mucunoides, *Dolichos lablab*, *Macrotyloma axillare* (cv. Jade), *Arachis pintoi* …
    - See also some species present in the communities : *Alysicarpus sp.*, *Indigofera* and / or *Tephrosia sp.* ; cf. **Photo 1** to **11.** for **local species** that could be collected and introduced in collection for further assessment)
  - grass sp.
    - ***Brachiaria*** *ruziziensis*, *B. humidicola*, *B. decumbens*, *B. brizantha* (cv. Marandu, MG4, MG5), Brachiaria hybrid (B. ruz x B. briz. , var. Mulato I, M. II, M. III), Panicum maximum (var. Tanzania, Mombasa, + eco-type from North Cameroon), Pennisetum purpureum (var. Paraiso), Bana grass (hyb P. typhoides x P. purpureum – by cutting)
- biomass production coupled by secondary grain production in an annual succession or association
  - legumes sp.
    - ***Cajanus cajan*** (collection of var.), *Vigna umbellata* (rice-bean), *Vigna unguiculata* (cowpea cv. of long cycle, > 120 days)
  - grass sp.
    - *Eleusine coracana* (collection of var. already introduced), *Pennisetum typhoides* (see local ecotype), *Sorghum bicolor* (collection to be regularly enriched and maintained), *Sorghum guineensis* (photosensitive)
- strict biomass production without any complement outputs for the production systems
  - legumes sp.
    - *Crotalaria retusa*, *C. spectabilis*, *C. juncea*, *C. zanzibarica*, *C. ochroleuca*, *Mucuna sp*.
  - grass sp.
    - Bamboo species (introduced from southern regions of Ghana → to be used for fencing and "hot spot" for erosion control, stabilization of gullies and rivers' banks

*For Midland and lowland*

- *Aeschynomene sp*.
- *Sesbania rostrata* and other sp.
- *Macroptilium lathyroides* (maybe already present in wetland)
- *Sorghum sp.* (Muskwari type → collection)
- *Brachiaria mutica*

+ local species to be collected and assessed in collection : *Tephrosia sp.*, *Aeschynomene sp.*, *Sesbania sp.* (cf. **Photo 1** to **11.**) and Desmodium sp. (spot seen in the plot 4.C of Panicum maximum in Upper Midland of Nyangpala station.

Due to the still limited capacities of local seeds multiplication, it is of utmost importance to sustain the development of the program to anticipate the needs and order from external supply source (Cameroun, Brazil …), during the dry season 2014-15:

- 100 kg of Stylosanthes guianensis
- 50 kg of Brachiaria ruziziensis
- 20 kg of Centrosema pascuorum

… to be combined with an active multiplication of *Crotalaria juncea*, *C. spectabilis*, *C. retusa*, *Cajanus cajan* and *Sesbania sp.*

*II-1-2 Collection for food crops and other annual crops*

- Legumes sp.
  - Cowpea, soybean, mungbean, rice-bean, pigeon-pea, groundnut, voandzu, …
- Grass sp.
  - Rice Sebota – *"Poly-aptitude"*
    - The following varieties has been passed to SARI and should be pre-multiply to be able to conduct multi-local assessment and selection under conventional and DMC management, in lowlands and upland
    - → Sebota 1, 4, 33, 36, 41, 47-12, 48, 63, 65, 68, 69, 70, 87, 147, 200, 254, 265, 270, 281, 330, 337-1, 399 (ex INT 146),
    - → Other varieties of interest, Primavera, Fofifa 3737, B 22, Sen Pidao, Pkha Rumduol (photosensitive - ps and aromatic -ar), P. Rumlong (ps-ar), P. Rumchang (ps-ar), P. Mlis (ps-ar), ACD 2526, ACD 2528, ACD 2540, Fedearroz 50, Coprosem 304, Espadon, Basmati 113, Basmati 122, Basmati 123, Basmati 370, Nerica 1, N.2, N.3, N.4, N.9, N.14

***N.B.*** Nerica 4, according to results get in Madagascar by Cirad, Fofifa and Africa Rice, present some resistance to *Striga asiatica.*

  - Maize (in breed var. –attention to isolation), sorghum, finger millet, …
- Other
  - Cotton, sunflower, cassava, yam, …

Among the introduced rice varieties -up to now only maintained in small scale collection-, few varieties should be actively multiplied under the responsibility of Dana:

- Short cycle (< 105 days): Sebota **68** (up. and low), 69 (up.) and 147 (up.)
- Medium cycle (105 – 125 days): Sebota 33, 48 (low), **63** (low), 200 (up and low)
- Long cycle (> 125 days): Sebota **36** (aromatic, low), **41** (low), Fed. 50 + Pkha Rumduol

Multiplication should be initiated, in counter season during the dry season 2014-15, in order to be get enough seeds to test these varieties in Station's fields in 2015 on both upland and low midland positions.

*II-1-3 Ligneous species*

- Legumes
  - Acacia auriculiformis, A. nilotica, Faidherbia albida, Cassia siamea, …
- Others
  - Ziziphus sp., Eucaplyptus sp., Tectona grandis … Could be multiply with Nwodua community in anticipation of communities' territory development (useful trees, corridor for cattle circulation, …).

**II-2 Evolution of the on-station experimental systems in 2015**

*II-2-1 Upland experimentation* (**Figure 1**)

*Comments and evolution of the cropping systems*

Stripe 3, 9, 15 Plow based reference – modeling of the dominant crop systems practices for maize production – 3 replications

Stripe 1, 2, 7, 8, 13, 14

DMC based bi-annual rotation Maize + Stylo // Stylo – Simple DMC proposal for rapid transfer and adaptation to farmers' communities (one year of "improved fallow" /2) – 3 replications

*Stripe 1, 7, 13 Stylo has been poorly implemented in 2014; it could be thus possibly interesting to complete the cover by an over-sowing of C. juncea in early May (to be decided in March-April 2015 during possible next mission); Maize is sown at 80 x 20 cm; Stylo is sown on 2 lines at 20 x 20 cm in the middle of the interrow, at 20 DAS of the maize and after complete weeds control (hand or Post selective weedicide application)*

*Stripe 2, 8, 14 Stylo is sown at 40 x 40 cm as soon as possible to get possibility to harvest seeds in 2015 on these plots*

Stripe 4 No Tillage based maize mono-cropping - this treatment aims at creating a "counter-demonstration" on this system that some farmers may adopt to make a fast, flexible and cheaper implementation of their maize

Stripe 10 DMC mono-cropping based on annual association between Maize short cycle (≤ 100 days) and Cowpea long cycle (# 130 days), producing grain and biomass

*Cowpea is sown on one line in the middle of the interrow, at 20 DAS of the maize and after complete weeds control*

Stripe 16 Modification with replacement of Stylo by *C. spectabilis*

DMC mono-cropping based on annual association between Maize and *Crotalaria spectabilis*, producing grain and biomass

*C. spectabilis is sown on 2 lines at 20 x 20 in the middle of the interrow, at 20 DAS of the maize and after complete weeds control (hand or Post selective weedicide application)*

Stripe 5, 6 DMC based bi-annual rotation Maize + Brach + Stylo // Brach + Stylo – Simple DMC proposal for rapid transfer and adaptation to farmers' communities

*Stripe 5 In 2014, Stylosanthes has been poorly implemented; only Brach is present; Brach will controlled by herbicide application (1 080 g/ha glyphosate + 540 g/ha 2,4 D amine), about 3 weeks prior Maize sowing; Maize is sown at 80 x 20 cm; Stylo and Brach are sown on 2 lines at 20 x 20 in the middle of the inter-row (alternatively, 1 inter-r. Brach, 1 inter-r Stylo), at 20 DAS of the maize and after complete weeds control (hand or Post selective weedicide application)*

*Stripe 6 In 2014, the mix cover has been badly implemented in association of Maize; it will be re-sown in 2015 and kept during the all rainy season*

Stripe 11, 12 DMC based bi annual rotation Maize + Stylo // Soybean + Sorghum + Stylo

*Stripe 11 Stylo hasn't been implemented in 2014 (late sowing of a too long cycle Soybean variety); the cover will be thus composed C. juncea sown in early May and kept growing for 45 days; Maize is sown at 80 x 20 cm; Stylo is sown on 2 lines at 20 x 20 cm in the middle of the interrow, at 20 DAS of the maize and after complete weeds control (hand or Post selective weedicide application)*

*Stripe 12 Stylo has been poorly implemented in association with Maize in 2014; it could be thus possibly interesting to complete the cover by an over-sowing of Sorghum in early May (to be decided in March-April 2015 during possible next mission)and kept growing for 45 days*

*Soybean is sown with*

- *a medium cycle variety (115-120 days) if sown before 20/6*
- *a short cycle variety (95-105 days) if sown after 25/6*

*Sorghum (non-photosensitive variety) and Stylosanthes guianensis are sown in soybean at the beginning of the defoliation (30% of yellow leaves) by broadcasting seeds at 25 kg/ha and 4 kg/ha respectively; soybean crop must be clean (use post selective herbicides fomesafen and fop family at 20 – 25 DAS)*

Stripe 17, 18 DMC based bi annual rotation Maize + Crotalaria retusa // Rice + Stylo

*Stripe 17 Stylo hasn't been implemented in 2014 in association with rice; the cover will be thus composed C. juncea sown in early May and kept growing for 45 days; Maize is sown at 80 x 20 cm; Crotalaria retusa is sown on 2 lines at 20 x 20 in the middle of the interrow, at 20 DAS of the maize and after complete weeds control (hand or Post selective weedicide application)*

*Stripe 18 C. retusa has been poorly implemented in 2014 in association with Maize; it could be thus possibly interesting to complete the cover by an over-sowing of C. juncea in early May (to be decided in March-April 2015 during possible next mission) and kept growing for 45 days; Rice is sown at 40 x 20 cm with a short cycle variety (e.g. SBT 68 or 147); Stylo is sown in the middle of the inter-row at 25 DAS of the rice and after complete weeds control (hand and/or Post selective weedicide application)*

**Figure 1**: updated lay out for upland rainfed cropping systems in 2015

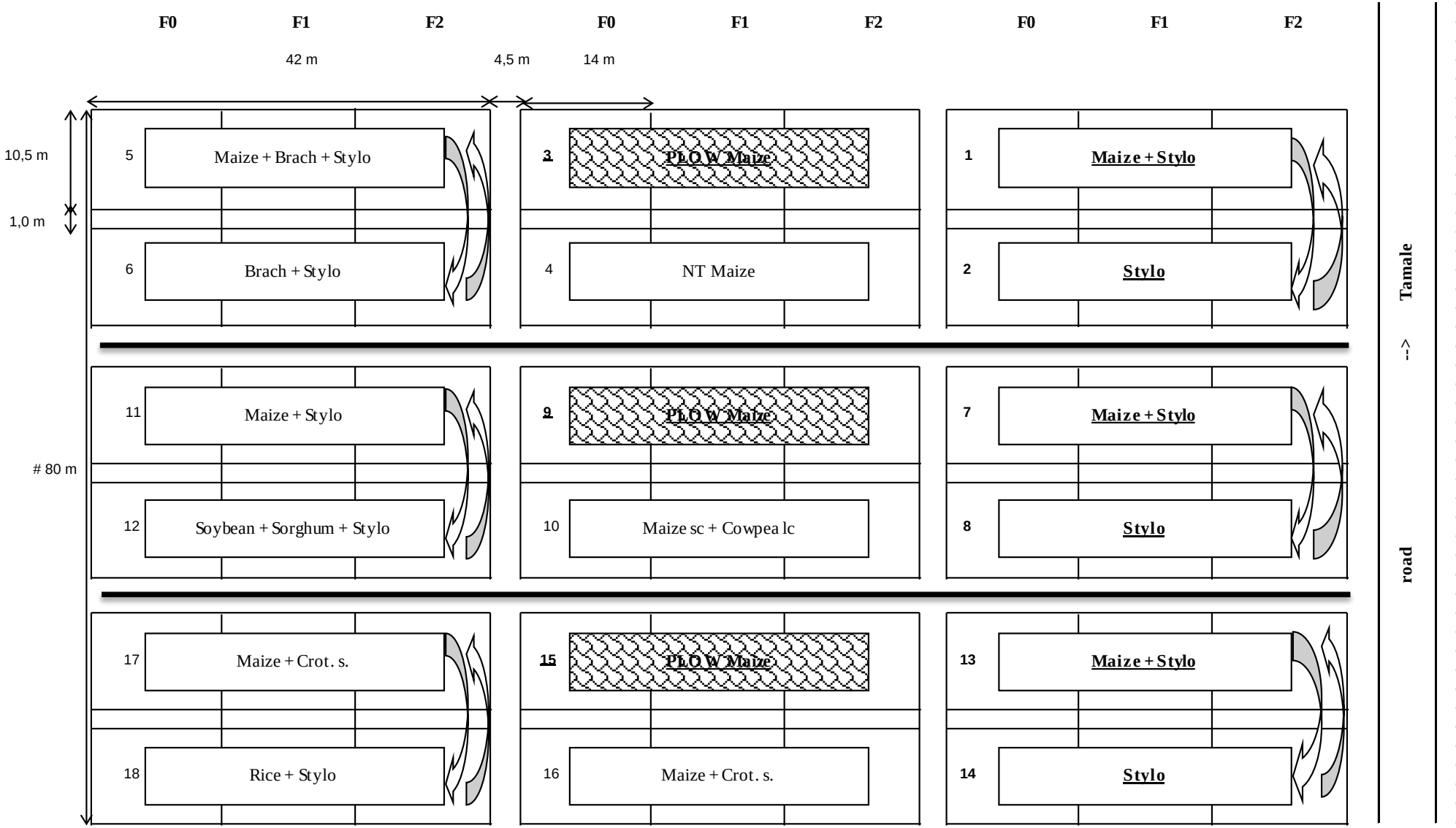


**Figure 2**: updated lay out for upper midland cropping systems in 2015

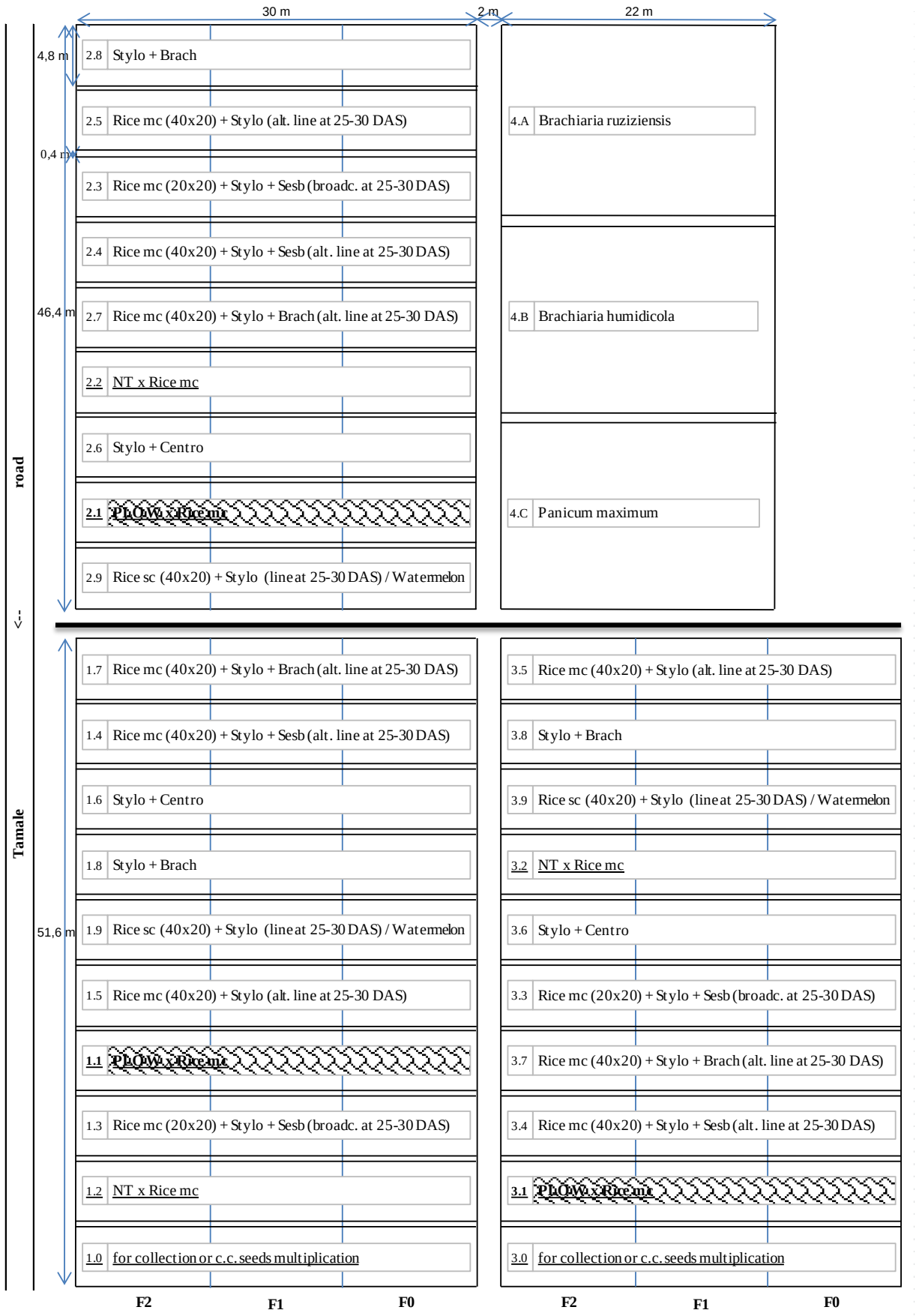
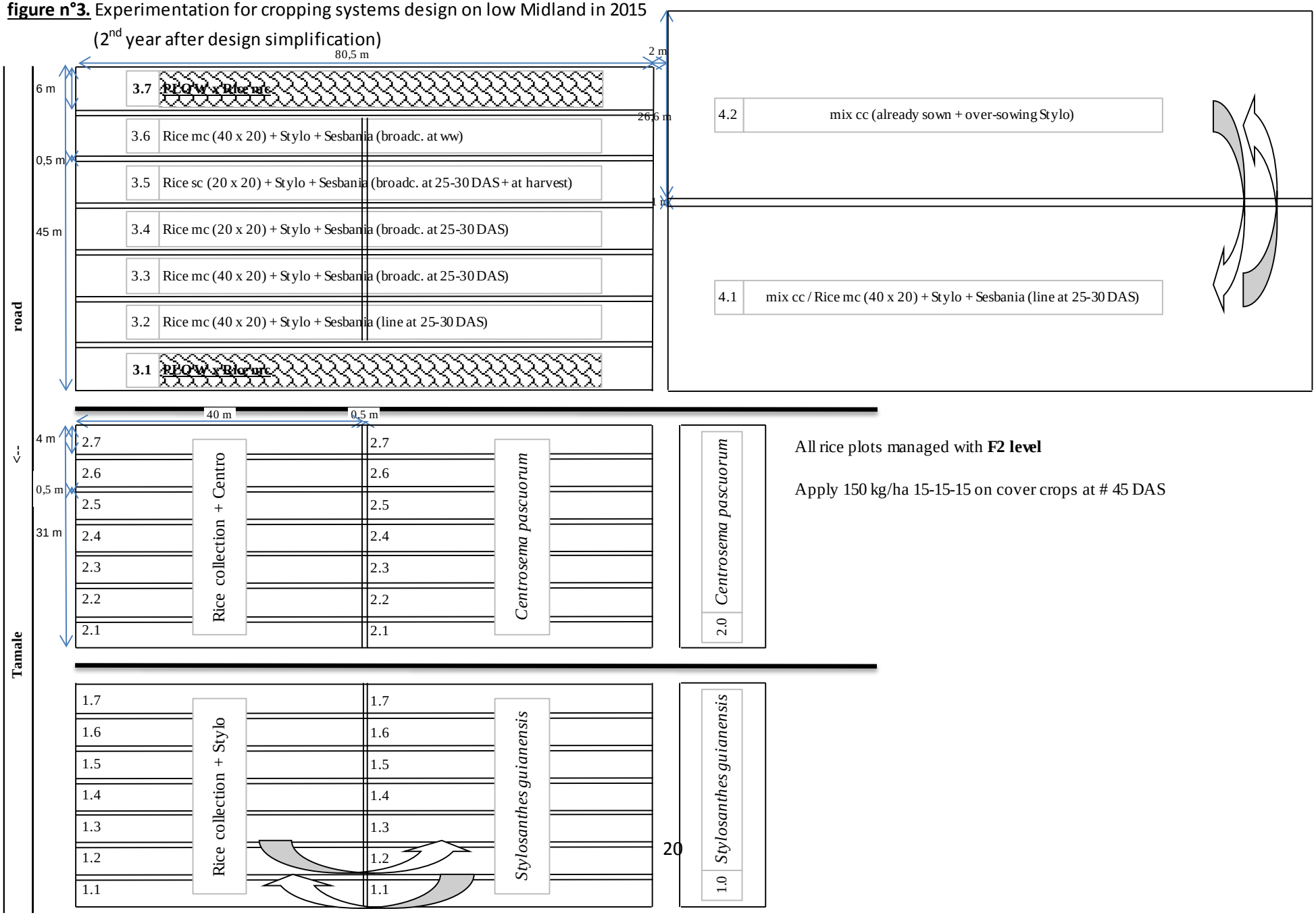


**figure n°3.** Experimentation for cropping systems design on low Midland in 2015 (2nd year after design simplification)




All rice plots managed with **F2 level**

Apply 150 kg/ha 15-15-15 on cover crops at # 45 DAS

*II-2-2 Upper Midland experimentation* (**Figure 2**)

Treatments remain unchanged but need to be adapted due to the absence of cover crop implementation in association with rice in 2014.

The varieties should be SBT 63 or, by default, Digang (if not enough seeds) for mc and SBT 68 or, by default Nerica 4, for sc.

| | |
|---|---|
| T1 | PLOW x Rice mc |

Plow based cropping system reference

| | |
|---|---|
| T2 | NT x Rice mc |

No-Till based system, i.e. direct sowing of the rice crops in Rice stubble of the previous cycle

| | |
|---|---|
| T3 | Rice mc (20x20) + Stylo + Centro + Sesb (broadc. at 25-30 DAS) |

DMC with labor extensive management for c.c. implementation

In April, NT sowing in rice residue of a Sorghum cover, kept growing 45-60 days before to be rolled and control by herbicide application.

| | |
|---|---|
| T4 | Rice mc (40x20) + Stylo + Centro + Sesb (alt. line at 25-30 DAS) |

DMC with more intensive labor management for c.c. implementation

Idem for short term "bio-pump" of Sorghum than T3

| | |
|---|---|
| T5 | Rice mc (40x20) + Stylo + Centro (alt. line at 25-30 DAS) |
| T6 | Stylo + Centro |

DMC based on a bi-annual rotation between Rice and cover-fodder crops; forage with a mix of 2 legumes species (in year 0 - 2014- and Year 1, there are none exportations of biomass to "model" a cut and carry practice for cattle feeding; to be initiated in Y2 for about a 1/3$^{rd}$ of the biomass available in December)

In 2014, Stylo + Centro cover were badly implemented and almost no cover crop were present in October; thus, in 2015, Rice on T5 is preceded by a short term "bio-pump" of Sorghum like on T3

| | |
|---|---|
| T7 | Rice mc (40x20) + Stylo + Brach (alt. line at 25-30 DAS) |
| T8 | Stylo + Brach |

DMC based on a bi-annual rotation between Rice and cover-fodder crops; forage with a mix of 1 legumes species with 1 grass species (in year 0 -2014- and Year 1, there are none exportations of biomass to "model" a cut and carry practice for cattle feeding; to be initiated in Y2 for about a 1/3$^{rd}$ of the biomass available in December)

In 2014, only Brach was properly sown on T8; according to its development in April 2015, it will be decided if the cover need to be completed, on T7, by an over-sowing of a short term "bio-pump" of Sorghum.

| | |
|---|---|
| T9 | Rice sc (40x20) + Stylo (line at 25-30 DAS) / Watermelon |

DMC based on an annual succession between a short cycle rice crop (< 105 Days) associated with a Stylo and a production of Watermelon, sown right after the rice harvest and straw spreading, on the rice line (at 8 m x 1,0 m, 2 seeds/hill, thin out at 1 plant After germination); the Stylo is kept growing during the watermelon cycle.

Idem for short term "bio-pump" of Sorghum than T3

No evolution in the permanent cover crop plots 4.A → 4.C that could only be extended by transplantation of cutting from July-August

*II-2-3 Lower Midland experimentation* (**Figure 3**)

*Test on cover crop implementation in association with rice crop*

In 2014, no cover crop has been associated to rice (var. Nabogo preventing any success in such attempt by its tall development and too long cycle) on the cultivated part of the DMC based treatments (T 3.2 → T 3.6) and only *Sesbania sp.* were sown on the remaining part of these 5 stripes.

In 2015, treatments remain unchanged. The variety is Sebota 63 or Digang if not enough seeds.

On plow based control, the 2 stripes (3.1 and 3.7) are entirely grown with rice. On DMC based treatments, rice is grown only on the 2014's Sesbania cover which may need to be oversown by a Sorghum short term bio-pump implemented at first rainfalls in April, if possible. This cover is controlled by rolling + herbicide application, about 2-3 weeks prior sowing. The remaining part of this 5 stripes (3.2 → 3.6), cultivated with rice in 2014, are mechanically sown with Stylo + Sesbania in alternate lines in June (before to waterlogged soil conditions).

*Varieties tests and collections*

Rice varieties are implemented on the part grown with cover crops in 2014 (*Stylosanthes guianensis* and *Centrosema pascuorum* on stripes 1.i and 2.i respectively) on 40 m long. The remaining part, cultivated in rice and cover crop in 2014 is sown with 2 cover crop species, Stylo and centro on on 1.i and 2.i respectively.

Proposal for varieties choice:

- stripes i.1 and i.7 - var. Digang (control)
- stripe i.2 – var. Sebota 63
- stripe i.3 – var. Sebota 36
- stripe i.4 – var. Sebota 200
- stripe i.5 – var. Sebota 41
- stripe i.6 – var. Sebota 48

Seeds are coming from the dry season 2014-15 multiplication conducted by Dana.

*"Real" scale demonstration*

On this demonstration, DMC based rice will be sown on the 2014 well-developed mix cover (**Photo 15.**) of the large stripe 4.1 (# 3 000 m²).

The mix cover is rolled by power tiller draught "rolo faca" (cf. infra) in mid-May and sprayed with 1080 g/ha glyphosate + 720 g/ha 2,4 D amine ; rice (var. Digang) is sown by Fitarelli (0,4 m inter-row) about 3 to 4 weeks after treatments. The mix cover crop (3 kg/ha Stylo + 15 kg/ha Sesbania + 1,5 kg/ha Indigofera) are broadcasted in rice stubble few days before (less than 7) or right after harvest, in October, according to water conditions on soil surface (no "free" water).

The 2014 rice stripe (4.2) is sown with a mix cover of Stylosanthes + Sesbania + Indigofera … + other spontaneous legumes sp. and annual grass weeds.

## II-3 Evolution proposal for the on community exchange and demonstration sites

The below proposals for both Upland and Midland agro-ecosystems must be considered as suggestions able to fit various farmers goals based on observations and exchanges in the 3 pilot communities. Real interests for such evolutions should be confirmed through discussions with committee's members that might lead to more or less pronounced amendments.

### *II-3-1 Upland demonstration sites*

On Upland situations (cf. **Figure 4**), proposals consist in offering choices between continuous cropping of Maize in association with cover crop (attempt to address high land pressure, systems of type 1) and bi-annual rotations between Maize + cover/fodder crop and the fodder crop (systems of type 2); another sub-option consists in a No-Till bi-annual rotation on crops residue between Cowpea and Maize (as more simple management and difficulty in controlling cattle access during dry season – should be keep in mind as a transitional stage in an adoption/ innovation process targeting change in cropping system and village territory development). Association and rotation (NT in crops residues or DMC) with legumes species could be specifically recommended to farmers to address problem of *Striga sp.*

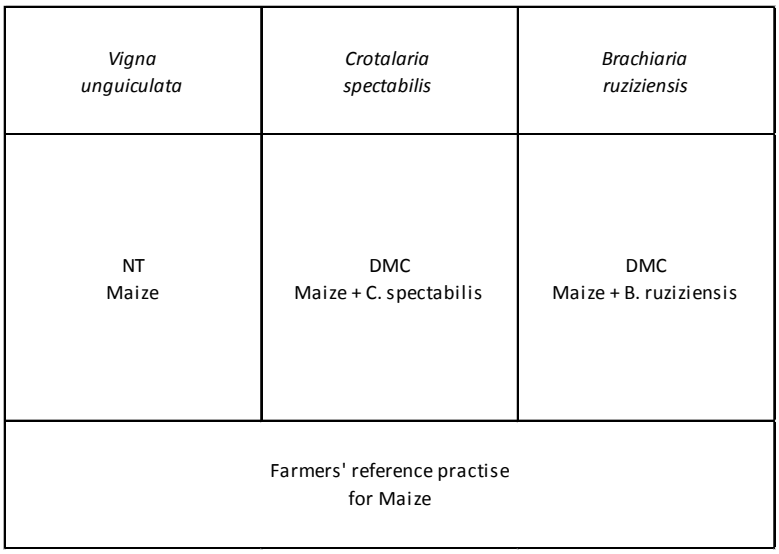
In lower land pressure and/or declared interest for fodder production, the Brachiaria could be kept several year as fodder source; maintaining *Brachiaria ruziziensis* in a good production potential requests to set a good control of cattle access (rotating grazing or cut and carry system); if impossible to set such a control, it will be preferable to adopt more hardy species like *B. decumbens* or *B. brizantha*.

Such orientation allowing the development of fodder source should be specifically discussed and proposed with the Fulani representatives, especially in Zugu and Jantong communities.

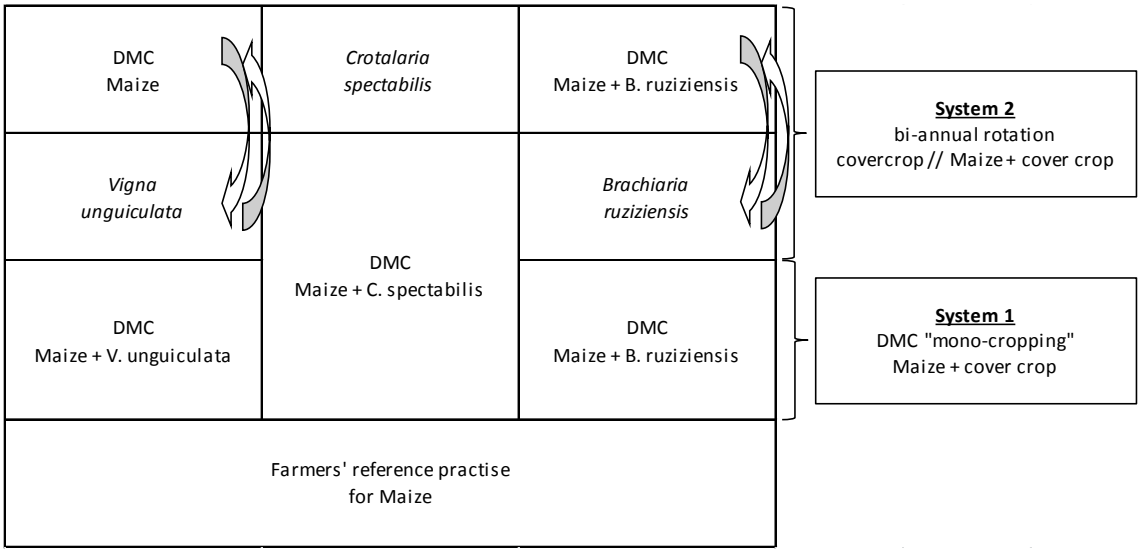
The plot of *Crotalaria spectabilis* is replanted for local seeds multiplication.

**Figure 4**: proposal of evolution in 2015 of the upland in-community demonstration site

***2014***




***2015***




*II-3-1 Midland demonstration sites*

It is proposed to cancel NT / DMC based management involving an early sowing (May – 1st half of June) of a Maize crop, later on intercropped by rice (cf. **Figure 5**); such proposition could be only maintained in Nwodua community which presents an intensive land management of its midland zones (not the case of Zugu and Jantong) in the "NT rice" system, in case of significant early rainfalls in May / June (sowing of Maize at 2,0 x 0,4 m).

New proposals mostly rely on the introduction of bi-annual rotation between Rice and Sorghum, which appeared as an important crop for Midland; in these rotations, the *S. bicolor* with short cycle and compact panicle

introduced 2014 on demo sites is replaced by the traditional variety of farmers (*S. guineensis*) presenting longer cycle and loose panicle. In these rotations, the sorghum is associated to cover / fodder crop (Stylo and Brach), opening possibility of longer rotation including development of (controlled) pasture / fodder production (especially in Zugu where part of the Midland seems to constitute an important open grazing area during the rainy season, the uplands being more densely cultivated). Sorghum (0,8 m x 0,4 m) are sown as soon as possible in May and cover crop about 20 DAS in the middle of the inter-row on 2 lines (0,4 m x 0,4 m)

Rice variety chosen by farmers seems to be Digang; small collections with new varieties could be introduced, according seeds availability, for participatory assessment.

**Figure 5**: proposal of evolution in 2015 of the midland in-community demonstration site

***2014***

| | | |
|---|---|---|
| *Brachiaria ruziziensis* | *Sorghum bicolor* "short" cycle | *Stylosanthes guianensis* |
| NT<br>Rice | DMC<br>Early Maize + Rice + Stylo | DMC<br>Rice + Stylo |
| Farmers' reference practise for Rice | | |

***2015***

| | | |
|---|---|---|
| *Brachiaria ruziziensis* | *Sorghum guineensis* long cycle | *Stylosanthes guianensis* |
| DMC<br>Rice + Stylo | NT<br>Rice | DMC<br>Rice + Stylo |
| DMC<br>Sorghum guineensis + Brach | | DMC<br>Sorghum guineensis + Stylo |
| Farmers' reference practise for Rice | | |

**II-4 Initiation of the pilot extension network**

This extension network is initiated in the 3 pilot communities with farmers interested by DMC technologies, i.e. some whole cropping system or only element(s) of DMC systems (NT planting, fodder crop, control of the plots access …).

It is based on a voluntary commitment of farmers after information and exchanges with research team and the village's committee. In the 2 or 3 initial years, some pilot extension could be suggested and then possibly negotiated with farmers in order to enlarge the scope of possibility and demonstration of DMC in the different village and households contexts. For instance, in 2015, some specific tests could be implemented after discussion with the committees on:

- direct DMC based cultivation of fallow land when covered by a significant biomass of mixed species, including legumes sp. ; such situations seem to be common in Jantong (upland and midland) and in Nwodua (upland); such fallow areas can be seen close to the demonstration sites and their cultivation in DMC should be discussed with farmers (avoid fire during dry season);
- development of fodder production (Brachiaria and Stylosanthes) with Fulani group, notably in Jantong and Zugu; several technical options could be proposed (in pure or in association with Maize –upland- or Sorghum –midland-) that could also lead in the future to specific land deal between Fulani group and farmers of the different communities (e.g. temporary land access for fodder production, fodder seeds production …)

Beside these specific orientations aiming at testing socio-technical hypothesis, the network should be developed under a limited number of technical proposals in order to simplify logistical support and messages and avoid confusion; in 2015, it could be based on:

- upland
    - Maize + *Crotalaria spectabilis*
    - Maize + *Stylosanthes guianensis*
    - Maize + *Brachiaria ruziziensis*
- Midland
    - Rice + *Stylosanthes guianensis*
    - Sorghum + *Stylosanthes guianensis*
    - Sorghum + *Brachiaria ruziziensis*

… the 2 association with Stylo (upland) and Brach (upland and midland) being proposed with the goal to develop fodder production involving a minimum control of the plot access by cattle during the dry season ; farmers has choice between 2 levels of "reasonable" fertilizers applications, similar to the ones commonly applied in conventional practices.

This network is developed as a partnership between research, farmers and their associations; it is based on individual contractual relations that precise role and respective responsibilities for farmers and research team. Research will propose contracted services for small mechanization (roller, DMC planter and also possibly spraying) with a clear grid of price. All exchange of money/service is accompanied with manifold receipts for transparent and non-conflictual management.

Farmers' plots should reach a minimum size (e.g. half acre / 2 500 m²) to avoid time consuming dispersion and too "marginal" interest of farmers. In first year of extension, a good quality of implementation and monitoring should limit this preliminary diffusion to a maximum of 15-20 farmers per community.

## III- Equipment use and on-station pilot for large scale DMC management

With the agricultural material received from Brazil, SARI is now able to develop and provide mechanization offers and services for DMC cropping systems implementation. These mechanization possibilities can address contrasted scope of operations:

- Small scale (for plot < 5 ha) based on power tiller draught
- Medium-large scale based on tractor of moderate power (100 HP to 125 HP for chisel plow)

### III-1 Small scale mechanization and pilot extension.

This level will be used for experiments implementation (significant scale and practice) and the pilot extension network.

It will request the acquisition of a power tiller (hand tractor of a min power of 12 HP) and the construction of:

- 1 roller with removable cutting disc (urgently needed, **Photo 18.**)
- 1 boom sprayer (optional, **Photo 19.**)
- 1 cart with access ramp for easy loading of material (Roller, Fitarelli planter …) that could be fixed to car for transport from village to village and to a power tiller.

### III-2 large scale mechanization and Nyangpala station development.

SARI should acquire skills in large scale DMC management on its own station before to retail services to private sector.

The offers will include:

- Soil profile restoration using chisel plowing
- Erosion control by contour line design using "taipadera"
    - fixed contour bunds every 40-50 cm heights covered by Brachiaria sp. on upland
    - transitory bunds in midland and lowland
- Land leveling and "puddling" in wet conditions by using heavy roller

and could be transferred and applied progressively on the all surface of Nyangpala station through a muti-annual plan of conversion to No-till and DMC.

The development of contour line request the purchase of a laser level kit

## Conclusion

*Next Cirad missions*

A possible and optimized allocation of the remaining budget for support missions to the SARI's R&D component of the RSSP has been discussed with the PCU and SARI's direction during the debriefing exchanges at the end of the mission. PCU has agreed to propose to the RSSP steering committee a prolongation of the Cirad support through backstopping missions on the 18 months prolongation; a 20 000 Euros budget has been suggested which combined with the remaining amount on the original budget (# 10 600 Euros) allow the financing of 3 missions with the below indicative schedule

| Period and duration | Expert | Topic and specific goals |
|---|---|---|
| 15 days<br>April-May 2015 | Stephane Boulakia | Adjustment of the R&D program, notably for the on-community pilot extension<br>DMC development plan for Nyangpala station<br>Training by doing to mechanization (in association with Mechanical Ag. Engineer from MoFA) |
| 10 days<br>October 2015 | Stephane Boulakia or Oumarou Balarabé | Debriefing of 2015 cropping season on both on Station and in-community activities<br>Communication (field days, conference)<br>Program proposal for 2016 |
| 12 days<br>April-May 2016 | Stephane Boulakia | To be defined with SARI and RSSP PCU according to development and relay partnership / funding. |

Further possible evolution

Ensuring long term evolution of the initiated program through the sought of relay funds and new partnerships (public and private) should be a permanent concerns for SARI's research team; SARI's direction should suggest it in its discussions with USAID and review possibilities of support through both the "Advance" program and the "International Lab. for Sustainable Intensification" that will be coordinated by Kansas University.

IFAD has also previously declared its interest that could be concretized into collaborative actions plans.

**Appendix 1**

Local weeds and cover of potential interest for DMC based systems

**Photo 1, 2 and 3.**
*Alysicarpus sp.* (*rugosus* -?-) on upland

*N.B.* A. rugosus is considered as a tropical fodder crops


**Photo 4 and 5.** Legumes species (*Tephrosia sp.* -?-) on upland ; soil macrofauna activities.


**Photo 6 and 7.** Legumes (*Tephrosia bracteolata or linearis* -?-) on Lowland


**Photo 8 and 9.** Legumes (*Sesbania pachycarpa* -?-) on lowland


**Photo 10 and 11.** Legumes (*Aeschynomene sp.* -?-) on lowland

**Photo 12 and 13.** Upland fallow covered by a mixture of Imperata cylindrica and a legumes (*Tephrosia bracteolata* -?-) on upland (Jantong community)

Up in June 2014 and bottom, in October 2014 → large surface that could be directly cropped in DMC

**Photo 14.** Other example of upland fallow covered by a mixture of sp. dominated by a legumes (Nwodua community, early October 2014)

**Photo 15.** Sub-spontaneous development of *Indigofera hirsuta* in association with Centrosema pascuorum (lowland in Nyangpala station, October 2014)

**Photo 16 and 17.** Good implementation of cc in association with maize: Crotalaria spectabilis cover in Nwodua (up), Brachiaria ruziziensis in Jantong (bottom) -October 2014

**Photo 17.** Erosion and damages on traditionnal bunds systems in period of heavy rainfalls (Midland in Nyangpala Station, October 2014)

**Photo 18.** 1,5 m width Roller with cutting discs for power tiller draught (designed in Cambodia by Cirad)

**Photo 19.** Power tiller draught sprayer with a 6 m boom (actioned by a pump of 1,5 HP, 120 l/ha) designed by ACIAR and CIRAD in Cambodia.