NO TILLAGE FOR SMALLHOLDER FARMERS IN SEMI-ARID AREAS (CAMEROON AND MADAGASCAR)

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1. Semi-arid areas

Semi-arid areas cover almost 20% of continental Africa and are characterised by a negative water balance a large part of the year. Their location, between unhealthy forest areas and arid deserts, makes that they were populated very early. As a result, population density is usually high in respect to their bearing capacity.

Population from these areas have developed for long production systems which are adapted to these situations:

1. **Transhumance** to exploit different agroecological areas all along the year for animal feeding,
2. **cultivation of drought-resistant species** (millet, sorghum, cowpea,…), at the right period to optimise water use efficiency.

However, demographic, climatic and economic changes now threaten these systems. Ploughing and reduction of fallow periods led to soil degradation, especially losses in organic matter not sufficiently compensated by the use of animal manure. Intensive practices (use of high-yielding varieties, chemical inputs, ploughing, etc.), often introduced for cash-crop production, showed their limits. Cotton yield, for instance, stagnates or decreases in most central and Western African countries.

Conservation agriculture proposes answers to this specific problem of soil organic matter as well as to the main cultivation constraints. Permanent soil cover, which reduces run-off, improved soil structure and early sowing (made possible as the time spent for ploughing with conventional techniques is spared) increase water use efficiency, nutrients use efficiency and consequently, yield. Cover crops also can be used as forages and thus contribute to a better integration between crops and livestock. But conservation agriculture has to be adapted to the specific constraints of the semi-arid areas, among which:

1. **The shortness of the growing season**,
2. the **heavy competition for the limited biomass** between farmers (soil improvement and mulching) and cattle raisers (forages), often belonging to different ethnic groups,
3. **farmers' limited investment capacity** and poor access to market.

2. SCV : Direct seeding on permanent plant cover

Various practices of minimum or without tillage, cover crops and direct seeding have been studied all over the world. However, Cirad and its partners, have developed cropping systems based on direct seeding with permanent plant cover (SCV: Systèmes de culture sur Couverture Végétale) (Séguy and Bouzinac, 2001). In these systems, the soil is never tilled but permanently kept covered by a dead or living mulch. The mulch comes from plants that are used as "biological pumps" in intercropping or relay-cropping systems. These plants have strong and deep root systems and can recycle nutrients from deep horizons for subsequent use by the main crop. They also have a high and fast biomass production and are able to grow in adverse conditions such as during the dry season, on compacted soil or under high weed pressure.

There are three main ways of implementing SCV (Séguy, 1998):

1. **Importing a mulch from surrounding areas**. These systems are very simple but are labour intensive and improvement of soil structure and nutrient recycling are limited.

2. **Producing the mulch locally**, using natural vegetation, crop residues or a cover crop grown in the field. It requires limited technical skills and labour but the cover crop can compete, in time or space, with the main crop.

3. **Using a cover crop kept alive** but controlled during the main crop cycle. This system is the most efficient but it requires high technical skills and is hardly feasible in semi-arid conditions. Systems with imported mulch usually are adopted first by farmers. Although their performances are limited, farmers can discover the advantages of a mulch regarding weeds control, water retention, erosion control, etc. However, for semi-arid conditions, systems based on mulch production in the field can be recommended.

As the short rainy season does not allow production of a cover crop before or after the main crop, it makes it necessary to produce an important biomass the preceding year. To achieved this, three main options can be proposed:

1. **Reclaiming fallow land**, using natural vegetation (e.g. *Andropogon sp*.) as a mulch.

2. **Improving the fallow lands** with, or cultivating, for at least one year, perennial legumes (e.g. *Stylosanthes sp.* or *Crotalaria sp.*) or grasses (e.g. *Brachiaria sp.*) which produce an important biomass and can rapidly regenerate degraded soils. These systems however are adapted only where population density is low enough to allow fallow periods.

3. **Associating**, at least one year over two, **a cover crop to the main crop** in order to produce a sufficient amount of crop residues for the next season. The cover crop grown in association is chosen according to the main crop (usually, association cereal + legume), its main role (soil structure improvement, N –fixation, etc.) and the possible uses for human and/or animal consumption.

3. Adaptation of SCV to semi-arid areas

3.1. Madagascar

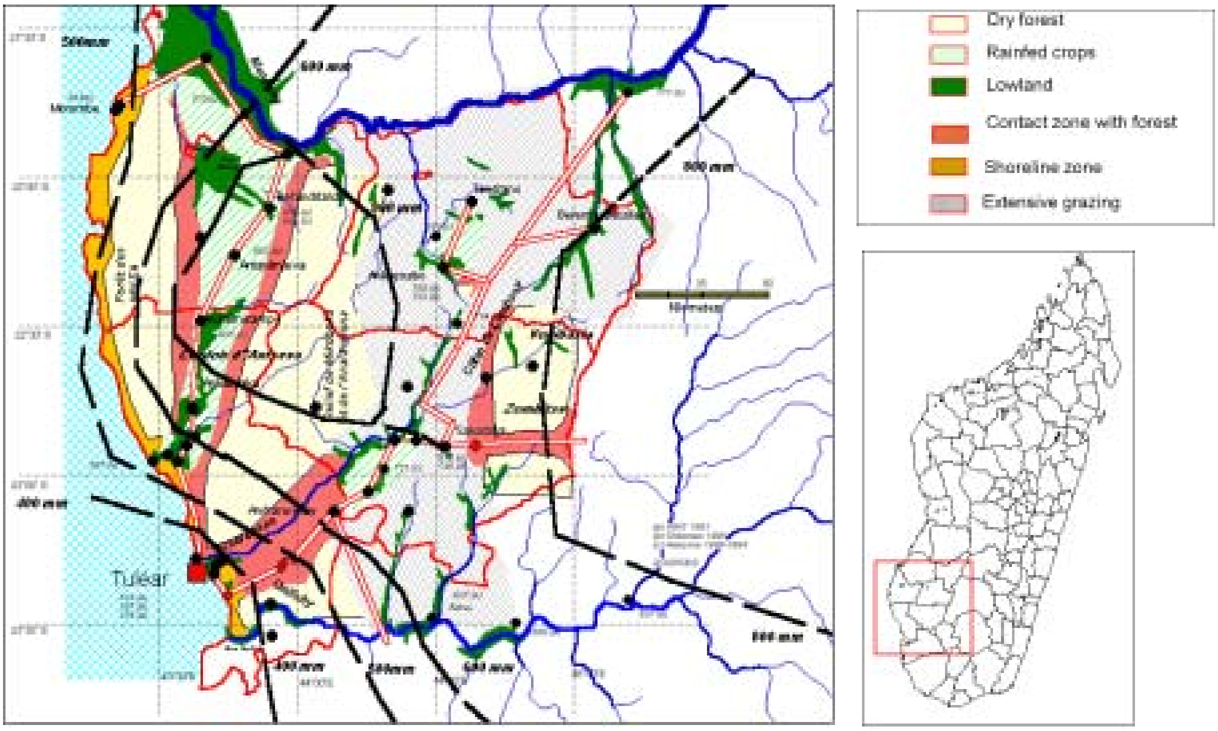
3.1.1. Semi-arid areas in Madagascar

Since 1991, CIRAD and its partners in Madagascar (NGOs as TAFA, national research as FOFIFA or development agencies as FIFAMANOR, etc.) have been conducting experiments to adapt direct seeding on permanent vegetal cover to various ecologies and socio economic conditions Two main zones have been selected for the semi-arid areas :

The South-West, around Tulear (since 1994/95), with cultivation for several years on savannahs after short fallow periods. Cotton is a major crop, with organised marketing channels. Slash-and-burn practices led to the destruction of old forests, grown under a former more favourable climate, and hosting unique and diverse flora and fauna. Local authorities asked for the development of new systems to preserve natural forests, increase and diversify agricultural production and make it sustainable (Rollin, 1997).

The Menabe, around Morondava (since 1998/99). Historically a region devoted to cattle raising, it evolves towards slash-and-burn cultivation of maize. Fallow periods between cultivation are longer than in the South-West, but the dry forest is being progressively replaced by savannahs with fallow periods averaging 5 years. Natural fallow is burnt every year by cattle raisers to insure forage production. Cotton is not cultivated (Charpentier and al., 2001).

In both zones, rainfalls, on average between 500 and 800 mm/year concentrated on 4 to 5 months, are extremely variable in space and show a high inter-annual variability (Figure 1). The experimental set up takes into account the various soil types met on a toposequence and the different water and vegetation conditions.



Map 1: South West Madagascar: location, isohyet and land use

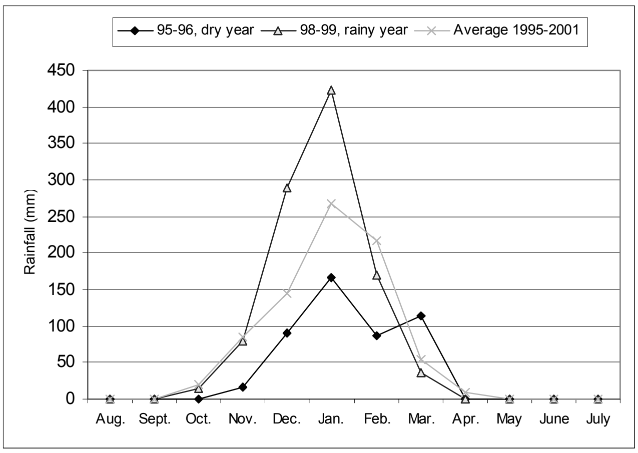


Figure 1 : Monthly rainfall in Sakaraha (Tuléar, Madagascar)

3.1.2. Main results

For both zones, direct seeding techniques proved highly more productive than ploughing, especially for cotton and maize (and upland rice in Morondava). Some basic principals for cultivation with direct seeding techniques emerge, especially for the strictly rainfed crops on alfisols ("sols ferrugineux tropicaux") sandy soils:

An early sowing, immediately after the first useful rain, on a soil covered with a mulch.

In such ecologies, it is capital to use all the available water and benefit from the high mineralisation at the beginning of the rainy season. Early sowing is made possible by direct seeding techniques when mulch is prepared in the dry season. It also is capital, on the fragile alfisols to permanently cover them with a mulch, from the first year, to prevent their hardening and to increase their water reserve (Rollin and Razafintsalama, 2001).

Restoring soil fertility

For a rapid raise of soil fertility, two solutions can be foreseen: Mineral fertilisation (for a cost of approximately 140 Euros/ha) which proved efficient, or soil smouldering, a low cost but labour intensive technique, enabling maize yield over 2.5 t/ha without mineral fertilisation but which must be used with caution on soil with low organic matter content, and recommended only to farmers having a good experience in direct seeding practices (Figure 2) (Charpentier and al., 2001).

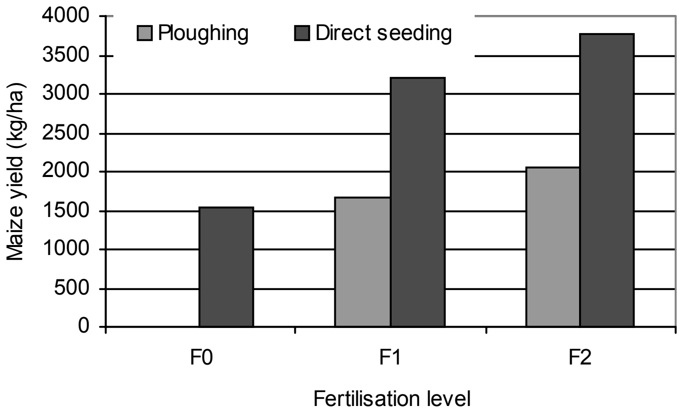


Figure 2 : Maize yield as a function of fertilisation level and land preparation. Maize associated to vigna unguiculata. Preceding crop : upland rice. (Morondava 2000/2001, Madagascar)

The first year, cultivation of crop associations producing an important biomass and able to improve soil structure.

Without such itinerary to increase soil fertility, the best solution to start direct seeding is to associate Sorghum with annual legumes with a long cycle such as *Dolichos lab lab*, *Vigna umbellata* or prostrated *Vigna unguiculata* which are well adapted to semi-arid conditions and can continue to develop in the dry season. These plants will improve soil structure, fix nitrogen, recycle nutrients and permanently cover the soil.

Crops rotations and associations

Once the soil has been improved, various crops can be cultivated but crops rotation remains a key issue to maintain soil structure and fertility and monocropping leads to yield decrease.

Thus, in the South-West, cultivation of cotton in rotation with an association cereals (maize, sorghum or millet) + legume (*Vigna unguiculata* or *Dolichos lab lab*) gives sustainable cotton yields, 2 to 3 time higher than with the usual practice of cotton mono-cropping with ploughing. In the Menabe, once soils have been improved by sorghum cultivation in association with legumes (2 to 3 years of cultivation for the poorest soils), all crops (rice, peanuts, maize, cotton, etc.) can be cultivated, but production, at least one year over two, of an important biomass is needed to maintain soil fertility (Figure 3, 4, et 5).

In the lower parts of the toposequence, on non irrigated lowland, soil smouldering also is recommended, and production of forages (either in association with crops or in full stand) able to develop in the dry season are interesting itineraries. (Figure 3, 4 et 5)

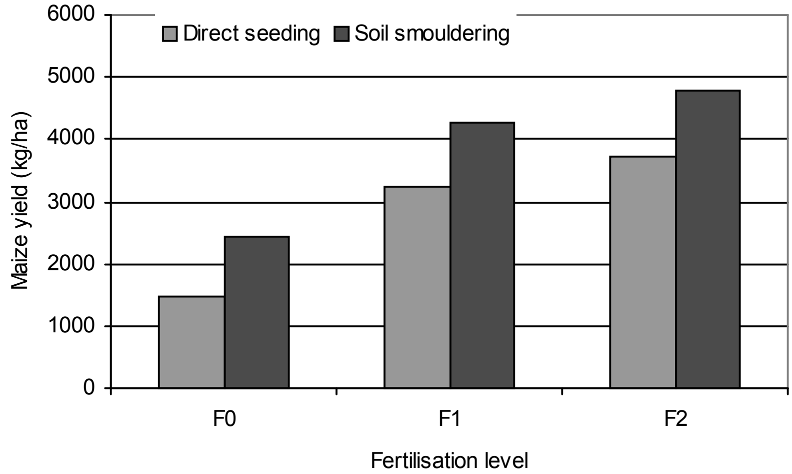


Figure 3 : effect of soil smouldering on maize yield Maize associated to Brachiaria ruziziensis. (Morondava 2000/2001, Madagascar)

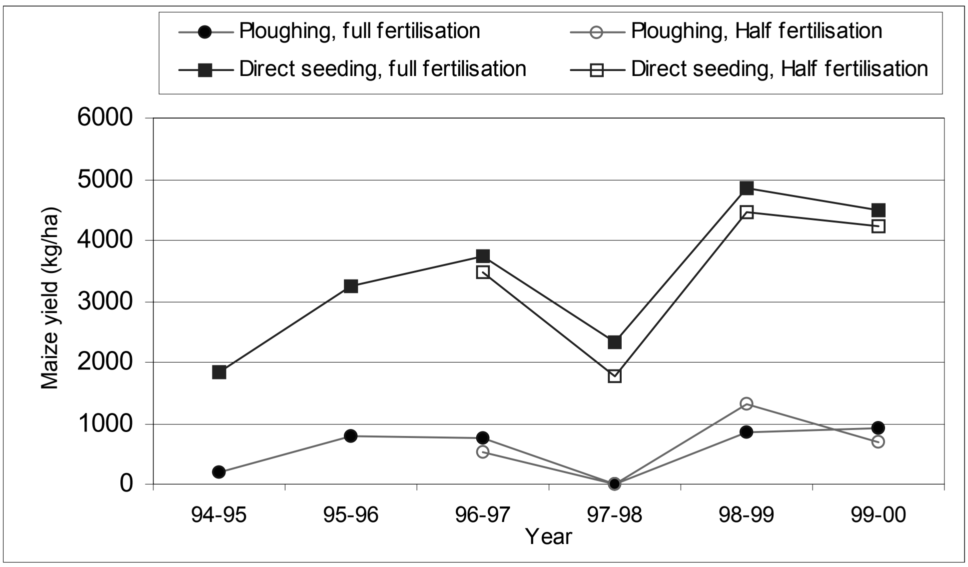


Figure 4 : maize yield as a function of land preparation and fertilisation level. (Tuléar, Madagascar)

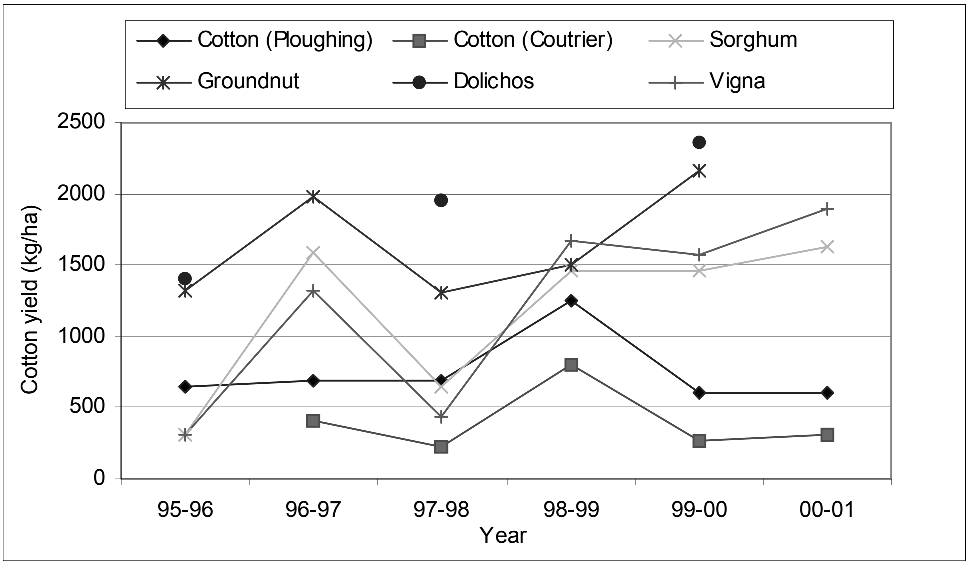
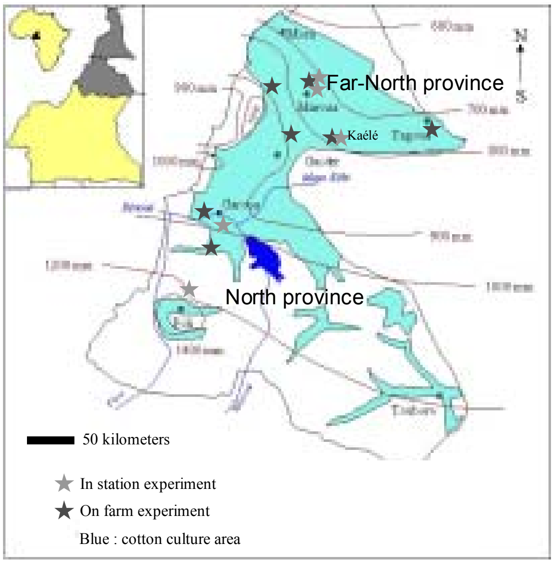


Figure 5 : cotton yield as a function of preceding crop and land preparation. Full fertilisation. (Tuléar, Madagascar)

3.2. Cameroon

3.2.1. Semi-arid areas in Cameroon



Map 2 : experiment location in North and Far-north Cameroon

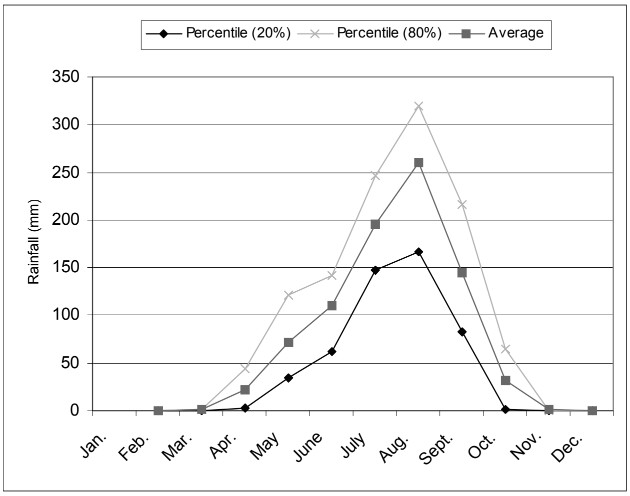


Figure 6 : monthly rainfall in Lara (Kaélé) Far-north province

The North and the Far-north provinces of Cameroon are very heterogeneous regarding rainfall (600 to 1400 mm) (Figure 6), relief (vast plains and steep mountains) and population density and history (200 hab/km2 in the mountains to 20 hab/km2 in the North). In the semi-arid Far-North, main crops are millet, rainfed sorghum, transplanted sorghum, cotton, cowpea and rice. Major crop rotations are cotton-cereals or cotton-legumes-cereals. Fallow are scarce. Livestock raising is based on transhumance excepted in the more densely populated areas (mountains and east of the province). Average farm size is moderated: 2 to 3 ha.

Addressing to the problem of decreasing fertility, donors finance since 2001 a project aiming at developing SCV technique for the Northern and the far- Northern regions. This project is implemented by a major actor of the development in this area, the cotton company: SODECOTON (Société de Développement de Coton du Cameroun) with the assistance of French and Cameroonian research : CIRAD and IRAD (Institut de Recherche Agricole pour le Développement).

3.2.2 Main results

Development of SCV techniques is threefold : in station experimentation initiated in 2000, on farm experiment started in 2001, and mixed experimentation (in the villages but under the supervision of project staff) which begun in 2002. The aim was to develop SCV systems based on the usual cereal-cotton rotation. In these systems, an important biomass is produced with the cereal and is used as a mulch for growing cotton the following year (Figure 7). Various grasses and legumes have been tried in association to maize or sorghum. Three of them showed interesting characteristics: i) *Brachiaria ruziziensis*, with a high biomass production, sustaining through the dry season ii) *Mucuna pruriens* with long cycle and fast growth, able to fix Nitrogen and useful to control weeds, and iii) *Crotalaria retusa*, which is spontaneous, does not compete with the main

crop, also able to fix Nitrogen and control weeds, and improving soil structure on compacted soils. Other promising plants such as *Dolichos lab lab* and *Eleusine coracana* still have to be tested on large scale:

Simple mulching of cotton fields with cereals or grasses straw also was tested with farmers in 2002. Although there is no soil structure improvement by a cover crop roots, the mulching effect allowed an increase in yield of at least 30% in more than half of the plots (Figure 8). Yield increase could even reach more than 200% in some fields. Yield as well as fibre quality indicates that SCV leads to a better water use efficiency (Figure 9) (Naudin, 2002).

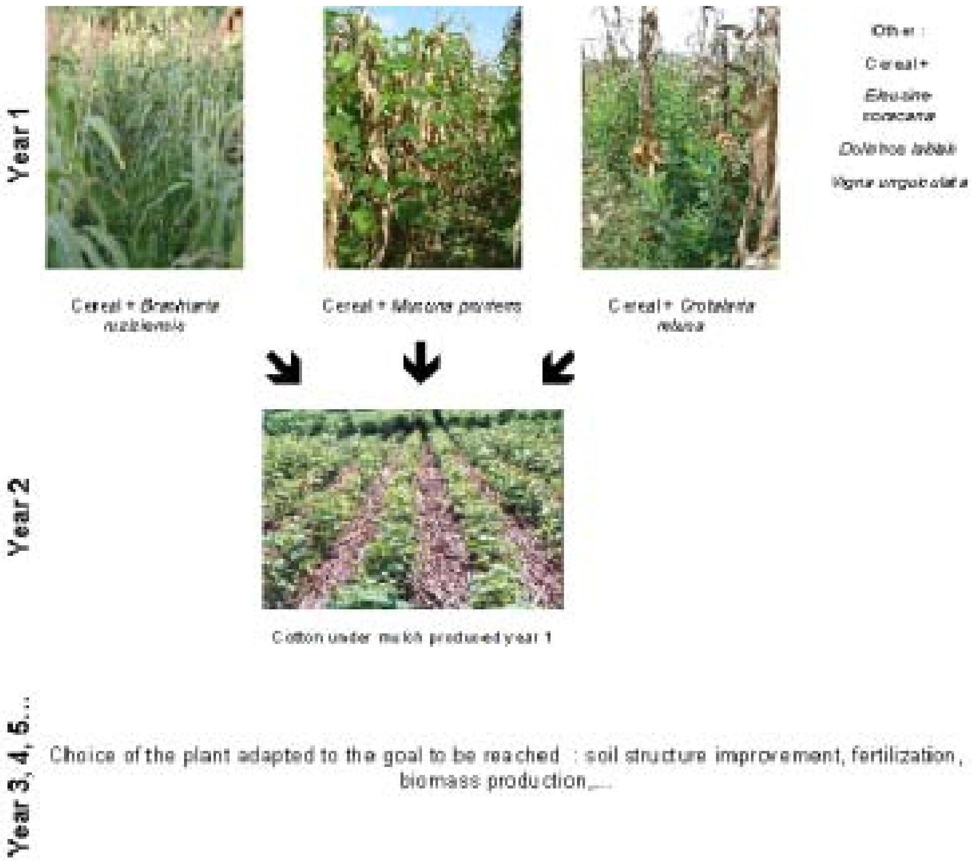


Figure 7 : adaptation of traditional rotation cereal/cotton under SCV system

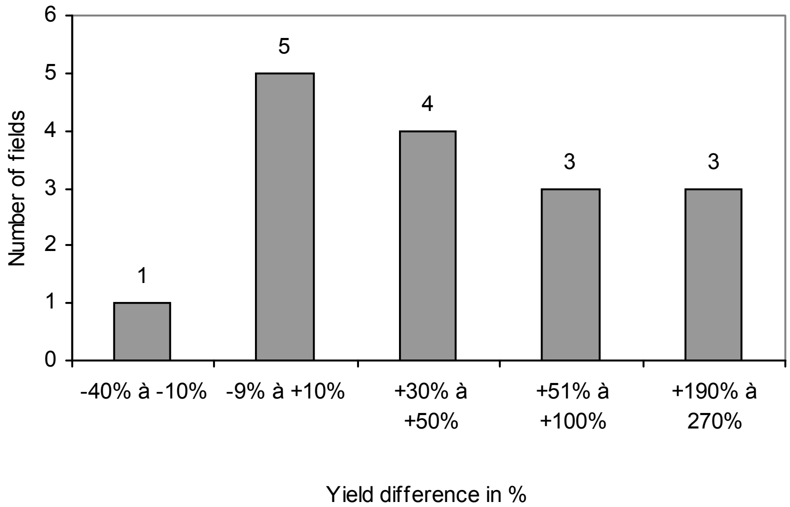


Figure 8 : on farm experimentation North and Far-north Cameroon 2002 Comparison between the SCV technique and traditional methods (direct sowing or tillage). Yield differences for the 16 harvested plot pairs.

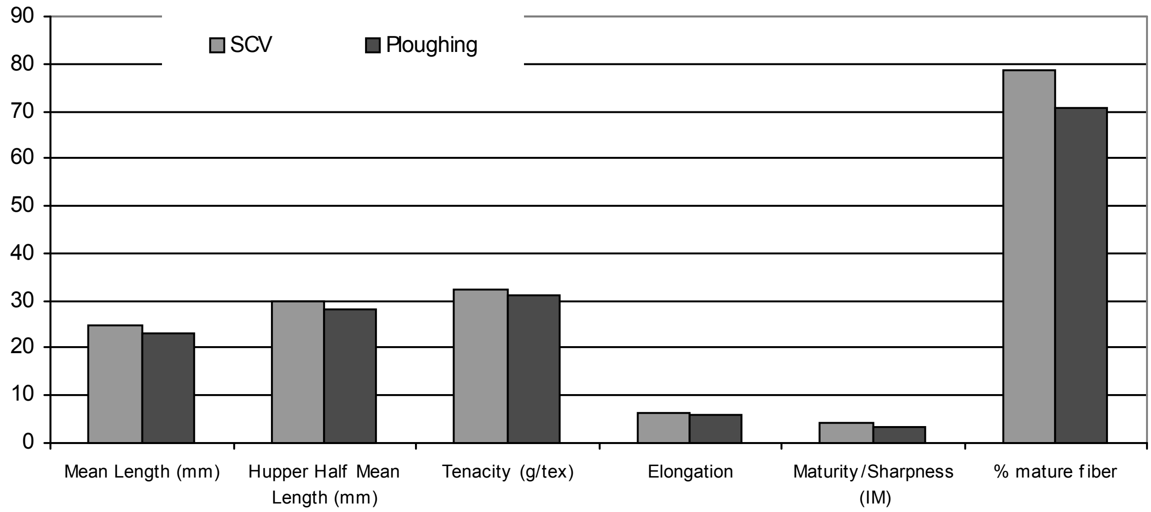


Figure 9 : in station experiment (Kaélé Far-north Cameroon 2000). Difference in cotton fibber quality grown under SCV or conventional methods.

Possible obstacles to large-scale extension of these systems are being studied. Although the advantages of SCV systems are clear from the third year, the first two years can show mixed performances. Complementary supply of nitrogen at cotton emergence, use of coutrier on dry soil and identification of cover crops less competing with the cereal can be recommendations for improvement of the performances of these systems at their beginning. Adaptations for better weed control and increased performances of the cereal/cover crop association (regarding soil structure improvement and biomass and grains production) still have to be finalised. Regarding animal husbandry, the main research axis aim at maximising biomass production in order to cover both the needs for soil protection and animal feeding. Also, better use of the available biomass (production of forage without burning the savannah, forage processing for improvement of quality and conservation) should be an important research axis. Finally, use of cover crops seeds for either animal feeding or human nutrition is a promising option.

4.Conclusions

Analysis of the production systems and the practices in the cropping systems in the North of Cameroon and in the West and the South West of Madagascar allowed to identify various constraints in traditional systems (as conducted by farmers since generations) as in conventional systems (proposed by the extension services).

Considering the whole farming system, in the economic and environmental context, new cropping systems have been proposed, associating direct seeding and permanent soil cover . They are very promising tracks to face the main constraints met with traditional or conventional systems. Within a few years, systems answering these main problems have been designed, enabling early sowing, reducing labor force bottleneck, reducing production costs, while enabling weeds control, increasing water use efficiency, stopping soil fertility degradation, and offering opportunities for better integration between crops and livestock, improving the quality and the quantity of the produced biomass.

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