

# Sweet sorghum: methodological exploration of a multifunctionality to innovate in Haitian agriculture

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## 1 Introduction

Sorghum is a hardy tropical plant, less demanding in water and nutrients, that can grow in poor soils. This cereal is used for human and animal consumption. While it is more used for animal consumption in developed countries, in Southern countries, it can represent an important part of the human diet, even if it is less and less popular.

Recently the international scientific community has been more and more interested by this plant particularly the sweet varieties (Damasceno *et al.*, 2014), which are able to combine a grain production with a sugar accumulation in their stalks giving them a multipurpose characteristic (Braconnier *et al.*, 2014).

In Haiti, a research and development project (S3F for Haiti) was implemented by CHIBAS (a Haitian foundation for agricultural research), Université Quisqueya (a Haitian university), and CIRAD (a French institution leading research in tropical agriculture), from 2010 to 2015, to introduce and develop sweet sorghum in Haiti. This multipurpose cereal, producing grains and sweet juice extracted from its stalks, can be used to produce bio-ethanol or alcohol while biomass (leaves and bagasse) left after juice extraction, represents a good source of forage or animal feed (Leclerc *et al.*, 2014). The development of these uses can provide an answer to Haiti's needs for food, feed and fuel.

The main question discussed in the project is to know how to assess *in itinere* the conditions to develop a cross-sectoral innovation, the sweet sorghum in Haiti. The hypothesis is that these conditions are revealed by: i) the analysis of existing and potential impacts on different sectors which are involved (animal feed, alcohol, human food), ii) the identification of the main bottlenecks, iii) the synergies between stakeholders (producers, industrials, State agents and research) around productions of information, knowledge, technologies and political orientations.

## 2 Materials and Methods

We mobilize the sectoral innovation system (Malerba, 2002; Touzard *et al.*, 2015) as analytical framework. This reference frame characterizes stakeholders system which is mobilized by the innovation process related to the introduction of a new cereal variety, and the conditions of its use in different potential value chains.

The analysis is structured by the sectoral dimension according to two macro-value chains related to food supply (human and animal) and energy supply. It provides a representative frame of the meso-economic relations in terms of vertical relationships between the different stakeholders (Temple *et al.*, 2011) involved in (1) production, (2) processing (grain, sugar and biomass) into intermediate and final products and (3) commercialization for the different uses (granule as cattle food, alcohol as “klerin” which is a local rum, syrup, bran, bagasse silage). It allows us to characterize the appropriate technological, economic and social conditions for sweet sorghum introduction.

An important set of secondary and primary data was collected throughout the project. Three surveys were achieved successively (Charles *et al.*, 2012; Lamour, 2013; Levesque, 2014) on a global sample of 70 resource persons from institutions and companies, that structure the Haitian system of research and innovation.

Direct face to face surveys were also conducted successively in 2012, 2013 and 2014 with samples of producers and industrials (small, medium and big processors) in various sectors.

During this study, the sweet sorghum implementation in different value chains was analyzed in three situations: in an industrial sugar cane area where we could find big “klerin”-processing plants, in a craft and hilly area full of small “klerin”-processing plants, and in the poultry industry area where sorghum can be used as animal feed.

## 3 Discussion

The sweet sorghum innovation can have different impacts on the development of Haiti. It can create jobs through the emergence of a new industry related to “klerin” production that would also stimulate the national sugarcane industry and sorghum grain production. The quantification of this job creation was appreciated by experimental observations realized in the different analysed situations. Thus, in the studied industrial area, from 61 to 131 man-months would be required, while in the hilly craft area the demand would be 60 man-months concerning industrial sectors. Moreover, sweet sorghum can maintain industries and agricultural activities based on sugarcane industry. For food producers, collecting grains in a production area requires people to organize the collection, and to load/unload grains.

The sweet sorghum innovation can also impacts positively on households' food safety through (i) an increased and

diversified income for producers giving them a better access to food and (ii) a higher grain yield from the sweet varieties. This innovation presents potentialities to use co-products in animal feed and could positively impact on the trade balance of Haiti through a decrease of corn and meat imports. The mobilized methodological framework permits to highlight the macroeconomic conditions to achieve these impacts from observations made on users' experimental devices.

Two types of factors limit the innovation processes and thus the achievement of the potentials impacts: technological and socioeconomic factors.

Considering the technological factors, the conditions of sweet sorghum use are heterogeneous in production areas, according to the priority given to potential uses of the stalks co-products ("klerin", animal feed...). It is necessary to adapt sweet sorghum varieties to these different uses. The use of sweet sorghum to produce "klerin" requires to reduce as much as possible the time to harvest and transport stalks process units for preventing °Brix decrease. To challenge these limits, technological, organizational and institutional (Paul, 2012) innovations in the supply chain are needed (moving mills, varieties, contracts).

About the socioeconomic factors, the use of sweet sorghum in industrial sectors (alcohol, animal feed) implies to consider the determinants of their competitiveness, partly linked to the orientations taken by commercial politics and public supports. The use of sweet sorghum grains as feed in the industrial poultry industry depends mainly on the price difference between sorghum grains and the competitor products, particularly imported maize. The use of bagasse as fuel for alcohol production implies to take into account the potentially negative social externality as this prevent other uses as feed for cattle, which play a saving role, or as soil fertilizer (organic matter and nutrients recycling).

Facing these bottlenecks, the adoption of this innovation requires to reinforce the technology as well as the organization of the activities to improve economic profitability of sweet sorghum use by the different stakeholders. Capacity to pool the supply logistics of producers and industrials as well as favourable orientation of public policies are two important axes to develop the market.

#### 4 Conclusions

The innovation, carrying potential positive impacts on the development and the households' economic situation, could be implemented and diffused only if the identified blocking factors are unlocked by adapted policies in research and innovation. A main issue is the development of interactions between stakeholders involved in the technological and organizational aspects that will determine future orientation of innovation processes. Nevertheless, this innovation may result in important upheavals through a reorganization of the livestock and a decrease in soil fertility, if no alternative is proposed to producers for replacing sorghum stalks left on the fields which play a role in the production system. Furthermore, this study strengthens methodological frameworks of *in itinere* assessment of the conditions for implementing an innovation in a context of Southern country agriculture.

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