Edible *Jatropha curcas* and sweet sorghum, two multi-purpose crops for food and energy security in Haiti

1. Introduction

Of a five-year total duration, the AKOSAA project is now into its fourth year of activity. With the financial support of Global Affairs Canada (GAC), it is implemented by Laval University (Quebec, Canada) and its Haitian and Canadian partners. It associates interventions in rural environments, innovations and capacity building with the aim of enabling Haitian agriculture to adequately address issues related to food security, nutritional deficiencies and climate change. Farmers, local and central state institutions, national and international organizations developing innovative approaches to agriculture and nutrition converge within the AKOSAA project towards the development and promotion of good agricultural practices, efficient value chains and improved nutrition. The project also promotes capacity building and the establishment of strategic alliances among the major players involved in agriculture and in nutrition.

With the Haitian Foundation CHIBAS, the AKOSAA project develops new agricultural value chains based on the use of multi-purpose crops, providing human food, animal feed and biofuels. The seeds of edible *Jatropha curcas* have a high oil content, and thus represent a source of fuel for lamps and stoves as well as of biodiesel. They are also rich in protein for incorporation in animal feed. On the other hand, sweet sorghum produces grain and a sweet juice fit for ethanol fermentation. Thus, these crops offer the promise of an increased food and energy security, and of a diminished pressure on the forest cover, as a consequence of a reduced dependency of households towards wood charcoal. In addition, the use of locally produced biofuel will free women, girls and children from exposure to the noxious fumes produced by charcoal fueling indoor cooking stoves.

We will summarize here the potential of edible *Jatropha* and sweet sorghum as means for improving food and energy security in Haiti.

2. Edible *Jatropha*

A multi-purpose shrub originating from Mexico and Central America, *Jatropha curcas* now occurs in a wild or semi-domesticated state in Haiti and most other tropical areas of the world. Vigorous and relatively drought tolerant, this plant is mainly used as a living fence component, since it is not eaten by animals such as cows, goats or sheep. Traditional uses of *Jatropha* include production of oil, soap, medicinal preparations from its seeds or other plant parts.

Edible *Jatropha curcas* (edible *Jatropha*, Euphorbiaceae; Gwo Medsyien in Haitian Creole) is grown and eaten by indigenous populations of Mexico and Guatemala,

especially by members of the Totanaca culture. It is totally free of phorbol esters, which are responsible for toxicity of most varieties of *Jatropha*. On the other hand, the Gwo Medsyien which naturally occurs in Haiti always correspond to a toxic, phorbol ester-rich, form of *Jatropha*.

The yields of the *Jatropha* crop vary between 1 and 4 tons per hectare, depending on soil type, fertilization regime and water supply. A significant production level can be reached after 2 to 3 years following planting and may last for up to 30 years. The seeds contain 30-40% oil which can be used as such in lamps and stoves or else be converted into biodiesel by transesterification.

Following oil extraction by pressing, a *Jatropha* cake is obtained which contains between 50 and 60% protein (which is more than for soybean cake). The amino acid composition of this protein is well suited for animal feeding, except for a low lysine content. Hence, the *Jatropha* cake harbors a high potential of use in animal feeding.

Jatropha cultivation can be performed on degraded land which is suboptimal for growing most other crops. Furthermore, *Jatropha* will contribute to land reclamation through production of litter (or dead leaves) and root exudates (which are organic products liberated by plant roots). The use of *Jatropha* for phytoremediation of contaminated land has also been examined.

Edible *Jatropha curcas* is destined to become a multi-purpose crop (useful for animal feeding and energy production), with a capacity to contribute to environmental rehabilitation (through reforestation and soil conservation) and extension of the agricultural land (through cultivation of marginal land). Edible *Jatropha curcas* would represent a local source of: (1) charcoal briquettes made from fruit and seed residues; (2) seed cake for animal feeding; (3) biofuel for lanps and stoves. The use of wood charcoal for family meal cooking would be substituted with that of briquettes and oil obtained from edible *Jatropha curcas*. The seed cake resulting from oil extraction from seed would be integrated as a protein source in poultry feed, as a replacement for the soybean seed cake currently imported at a high cost in Haiti.

Since its inception in March 2013, the AKOSAA project financed by GAC supports the development of a value chain based on edible *Jatropha curcas*. With its Haitian partner, CHIBAS, it has developed a genetic improvement program for edible *Jatropha* through conventional breeding, with the aim of developing new varieties that will be well adapted to local agroecological conditions. It has also elaborated an efficient process for oil extraction and demonstrated that *Jatropha* seed cake could replace soybean seed cake as a component of feed for broiler chickens and laying hens, without any significant decrease in production. Finally it has verified that chickens fed jatropha exhibited no sign of intoxication and that their meat contained no trace of phorbol esters.

CHIBAS has conducted preliminary tests involving the use of edible *Jatropha* oil produced in Haiti to fuel the stove/burner PROTOS of Bosh-Siemens (BSH), with positive results. BSH is a member of the Global Alliance for Clean Cookstoves, with the

aim of finding innovative solutions to the global health and environmental problems caused by open fires.

The use of multi-purpose edible *Jatropha* varieties will create new market opportunities for the *Jatropha* value chain. Edible *Jatropha* will make it possible for Haiti to reorient budgets away from fuel importation and towards its farmers. Furthermore, the protein-rich seed cake will be incorporated in balanced feed for livestock farming and hence *Jatropha* will simultaneously contribute to food and energy security of the country.

3. Sweet sorghum

Sorghum (*Sorghum bicolor*, Gramineae; pitimi in Haitian Creole) is commonly grown in Haiti, where it primary yields grain for human food and animal feed. Leaves and young shoots may be used as fodder. Some sorghum varieties, denominated sweet sorghum varieties, offer the advantage of producing grain while simultaneously accumulating sweet juice in their stem. Thus, sweet sorghum is a multi-purpose crop yielding human food (grains), animal feed (grains, as well as leaves and bagasse following juice extraction), and also sweet juice accumulating in the stem. This sweet juice can be processed into syrup (similar to sugarcane syrup already produced in Haiti), and its conversion into ethanol has been thoroughly studied, from both an economic and energetic standpoint. The juice extracted from sweet sorghum stems contains between 14 an 19% of sugars, sucrose, glucose and fructose, which yeast can easily ferment into ethanol.

Since it is less demanding in water and nutrients than sugarcane, sorghum is better adapted than this other crop to dry and low-fertility environments. Being the third cereal crop in importance in Haiti after rice and maize, it is grown on 120 000 hectares of land. It is commonly grown in association with other crops, maize, beans or other legume crop.

In Haiti, farmers have traditionally retorted to non-sweet varieties which, in addition, are photoperiodic, meaning that in these varieties flowering and grain production depend on natural variation in daylight duration. This tends to increase the time delay required for completion of the production cycle. On the other hand, the Papésèk variety, which was introduced in Haiti in 2002, is non photoperiodic variety (hence with a shorter production cycle), which combines sugar production with a relatively high grain yield. Whereas it currently is the most popular sorghum variety in Haiti, it is relatively sensitive to the sorghum and sugarcane yellow aphid, which has recently arrived in Haiti.

With its Haitian partner CHIBAS, the AKOSAA project has demonstrated to farmers that sweet sorghum stems could be pressed in the mills that are already in use for sugarcane processing, with extraction of a fermentable juice. Genetic improvement trials are currently in progress, through breeding Papésèk with a second sorghum variety called Dékabès, with the aim of improving the sugar content of Papésèk without significantly reducing its seed production capacity. It is also intended to obtain sorghum varieties with good resistance to the sorghum and sugarcane aphid. Hence, several populations have been created, so as to select a sorghum line producing as much grain as Papésèk and with

a drought tolerance similar to that of that variety, while harboring a juicy and very sweet stem.

CHIBAS has also produced a sweet sorghum alcohol gel. This alcohol gel can be used as fuel in basic stoves and also as a substitute to fat wood (bois gras; resinous wood used as a fire starter and produced through the exploitation of the last high-altitude resinous forests in Haiti). The liquid alcohol produced from sweet sorghum has also been tested successfully in alcohol burners (model burner made by Domestic).

The various uses of multi-purpose sweet sorghum will allow rural populations to improve their livelihood through an enhance valorization of agricultural products and the establishment of new value chains that will increase revenues and provide new jobs.

4. Innovation needs and conclusion

Given the current situation and energy costs, it appears quite clearly that the recourse to crops exclusively dedicated to biofuel production will not be profitable, particularly within the context of smallholder Haitian agriculture. To be in a position to develop this renewable and relatively clean energy source, it will be necessary to pursue and intensify innovation efforts currently deployed in Haiti. In particular, the following aspects ought to be considered:

- Develop complementary value chains associated to multi-purpose crops: production of grain and animal feed, briquettes, silage and others.
- Improve varieties of edible *Jatropha* and sweet sorghum, so as to increase their adaptation level to local agro-ecological conditions, their tolerance to diseases and pests and their yield.
- Perfect the technical itineraries so as to ensure production of biofuels and derivatives under conditions incompatible with staple crop maintenance, but with nevertheless acceptable yields.
- Evaluate the advantages associated with the use of perennial oil-producing crops, including edible *Jatropha* and other multi-purpose trees, in agroforestry strategies associating food and biofuel production.
- Optimize the effects of perennial oil-producing crops on quality and conservation of natural resources, particularly soil and water, and document the impact of these crops on resilience of the Haitian agriculture and economy in the face of climate change.
- Optimize the compatibility of biofuels with household culinary practices and stoves, so as to reduce indoor pollution and improve respiratory health of women, girls and children.
- Estimate the production costs of biofuel based on sweet sorghum ethanol (liquid ethanol or alcohol gel) and of *Jatropha* oil, as well as consumer costs.

Finally, considering the economic and cultural importance of the charcoal value chain in Haiti, the development and promotion efforts outlined here should be accompanied by

initiatives to improve the sustainability of wood charcoal production and to minimize the negative impact of its domestic use on the health of women, girls and children. Recent observations tend to show that certain zones of the national territory have become specifically devoted to charcoal production while experiencing an increase in tree cover. It would seem advisable to better understand these local initiatives and take advantage of these in order to ensure, in due course, an harmonious transition away from charcoal and towards alternative energy sources.

The AKOSAA project and CHIBAS have already undertaken to carry out this innovation program, with encouraging results which can be made available to all interested parties. The development of these innovations constantly occurs under a participatory action research regime, so as to elicit the involvement of farmers and ensure an immediate adequacy between the results of the innovation and the needs and reality of smallholder Haitian agriculture.

Considering the food insecurity which currently prevails in Haiti, any effort dealing with the establishment of biofuel value chains will systematically be confronted to the fragility of agricultural systems. The use of multi-purpose crops, concomitantly yielding biofuel and food, will make it possible to reconcile food and energy security, while contributing to farmer revenues increases, environmental protection, resilience in the face of climate change, and respiratory health of women, girls and children.

July 14, 2016