Croton megalocarpus **grows in the semi-arid to sub-humid highlands, and is common around Nairobi. It can grow into a big tree, of great ornamental value.** *(Photo: BGF)*

Which way jatropha and croton oils?

Characteristics of the two biofuels, compared to diesel, and their availability or eventual production possibilities

By Nellie Oduor

Biofuels are fuels made from plant and plant derived resources. These fuels are used mainly for transportation. There are two types of biofuels – bioethanol and biodiesel. Bioethanol, the principal fuel used as a substitute for petrol for road transport vehicles, is mainly derived from maize and sugar cane. Biodiesel, on the other hand, is mainly produced from oil crops such as jatropha, rapeseed and soybean.

Biomass fuels are the most important source of primary energy in Kenya, with wood fuel consumption accounting for over 68 per cent of the total primary energy consumption (Ministry of Energy, 2004). Current supply sources of fuel wood are on-farm production, which accounts for 84 per cent, and trust lands and gazetted forests each with 8 per cent.

The majority of Kenyans depend on wood and charcoal for cooking and heating. Over 90 per cent of rural households use firewood for cooking while 80 per cent of urban households depend on charcoal as a primary source of fuel for cooking. This charcoal is produced in the rural areas inefficiently and often, in an unsustainable manner. About 2.5 million people depend on the charcoal trade either directly or indirectly and charcoal contributes Ksh 32 billion to the national economy (ESDA, 2005). Many rural people depend on charcoal for income generation and in most cases, charcoal is the main source of this income.

Following the oil crisis of the 1970s and recognition of the limitations of world oil resources, plant species which can be processed to provide a diesel fuel substitute have received special attention. Most of the research was carried out in temperate regions with the aim of making available to farmers possibilities for diversifying in view of the increasing subsidy-driven surpluses in traditional commodities.

Another argument for the cultivation of oil crops for energy is the increasing global warming/greenhouse effect. It has been established that for every 10 tonnes of fossil fuel burned, 3 tonnes of carbon dioxide (CO_2) is released into the atmosphere. When biofuels are burnt, the atmosphere is not polluted by extra carbon dioxide, since this has already been assimilated during the growth of these crops. The CO_2 balance, therefore, remains equable.

To be a viable substitute for a fossil fuel, an alternative fuel should not only have superior environmental benefits over the fossil fuel it displaces, be economically competitive with it, and be producible in sufficient quantities to make a meaningful impact on energy demands, but it should also provide a net energy gain over the energy sources used to produce it *(J.Hill et.al, 2006)*.

Promising oil crops currently being investigated in Kenya are the seeds of *Jatropha curcas* and *Croton megalocarpus*.

Jatropha curcas

Research has shown that *Jatropha curcas*, whose oil-producing seeds are toxic to humans and most animals and birds, has merits as a viable alternative for production of biodiesel. *Jatropha curcas* is a multi-purpose, shrubby tree belonging to the *Euphorbiaceae* family. It is native to Mexico or Central America, but now thrives in many parts of the tropics and sub-tropics in sub-Saharan Africa and Asia. Jatropha has received tremendous attention around the world over the last few years due to its potential as a biofuel crop.

While the plant is not indigenous to Kenya, it has been naturalised in many parts of the country. Farmers have been growing it for many decades for reasons other than as biofuel. One finds many trees older than 30 years grown as fences or in the wild.

In 2000, a few farmers in Siaya, Vihiga and Bungoma West districts introduced jatropha as feeders to support their vanilla vines. The jatropha was planted, not for oilseed, but to serve as a host for the more lucrative vanilla crop, which can fetch up to Ksh 3,000 per kilogram. As a result, no effort was made to nurture the jatropha to produce seeds. It is only in the last few years that jatropha has become widely known as a potential biofuel feedstock in Kenya.

Croton megalocarpus

This is an indigenous (East Africa) upper-storey forest tree from the family *Euphorbiaceae* that grows to 35m or more. Its range is the semi-arid and sub-humid highlands, at altitudes between 1200 and 2450m, with an annual rainfall of about 800 to 1600mm and average annual temperatures varying between 11 and 26°C.

Trees of this species are found in forests and often on farms as boundary markers, windbreaks, shade trees and fuel wood producers. The tree is also found in moist upland forest, dense woodland (especially riverine or near springs) and scattered tree grassland. It is estimated that millions of trees are growing in the wild and on farms throughout the country.

Croton is a multi-purpose tree that provides a wide range of direct and indirect uses and services. Its timber is commonly used for making agricultural implements, in construction, joinery and furniture, and for provision of posts and poles for fencing. Croton is also used for firewood and charcoal. The leaves, seeds, bark, roots and wood extracts from the tree are used as medicine for humans and livestock, including for the treatment of stomach ailments, malaria, wound clotting and pneumonia.

As an indigenous species planted in homesteads, community centres and marketplaces, croton provides shade and shelter and acts as a windbreak. Mature trees have deep taproots, which access fertilisation to augment soil nutrients, while roots exudate enrich soil with minerals and leaf litter rich in nitrogen, phosphorus and organic carbon.

Croton trees improve and stabilise soil through water retention and erosion retardation, thus minimising the loss of valuable topsoil and the siltation of rivers and lakes. Currently, there are various activities involving croton at global, regional and national levels.

Croton seeds produce inedible oil that is suitable for biofuel. Various academic institutions are undertaking pharmacological studies to evaluate potential of croton for medicinal uses, its toxicity and formulations for croton seed meal for animals. Claims that croton species have high potential for production of essential oils are being investigated as well.

Croton trees seed prolifically in October - December in central and northern Kenya and in January - February in western Kenya. Frequency of flowering, number of spikes, number of female flowers per spike, number of seeds per fruit and seed weight are all factors that influence yield.

Currently, there is scant information on yield per tree because of a historical lack of demand for the seeds. However, the potential yield of mature trees has been assessed at about 25kg per year, with some projections as high as 50kg. A systematic study is needed to determine yields under different growing conditions and within varied agro-ecological zones.

***Fruits of** Croton megalocarpus. **The seeds germinate easily and if protected, regenerate naturally without problems. When pressed they can yield up to 30% of good quality oil.** (Photo: BGF)*

***Fruits of** Jatropha curcas **being dried in the sun before seed extraction (de-hulling).** (Photo: BGF)*

There is limited empirical data on the economics of growing croton either for biofuel or timber. Croton oil seeds in the hard outer hull are currently sold to local buyers for Ksh 5 per kilogram. The buyers then mechanically de-hull the seeds and press and filter the oil for use locally as straight vegetable oil (SVO) and biodiesel.

Typically, the current practice is that the seller makes arrangements for the buyer to pick up the seeds from the farm gate. This is why no transport costs are included in the price, as they are borne by the oil processers/buyers and not the farmers.

Seeds out of the hull currently sell for between Ksh 12 - 20 per kilogram. The only consistent market for the seeds appears to be in Central Province where two processors press croton oil.

The Kenya Forestry Research Institute (KEFRI) is involved in research for production, processing and marketing of croton for biofuels and reforestation. KEFRI's National Seed Centre provides certified, high quality croton seeds to farmers throughout the country. Jomo Kenyatta University of Agriculture and Technology (JKUAT) and the Kenya Industrial Research Development Institute (KIRDI) are testing the use of croton oils as biodiesel feedstock.

The Naro Moru Help Self Help Group and Horizon Business Ventures at the base of Mt Kenya produces croton oil for biodiesel and straight vegetable oil (SVO) biofuel, using a small biodiesel reactor and several oil presses obtained with donor assistance. The organisation also presses edible oils from sunflower and rapeseed grown by surrounding farmers.

The Enterprise Development Centre, a community-based organisation also operating in the Mt Kenya region, is involved in a pilot project producing biodiesel from croton seeds. The seeds are collected manually from farmlands within the region by youth who sell to the processing factory. The organisation claims to produce 400 litres per day.

Table 1: Comparison between croton and jatropha SVO with the Kenya Diesel Standards

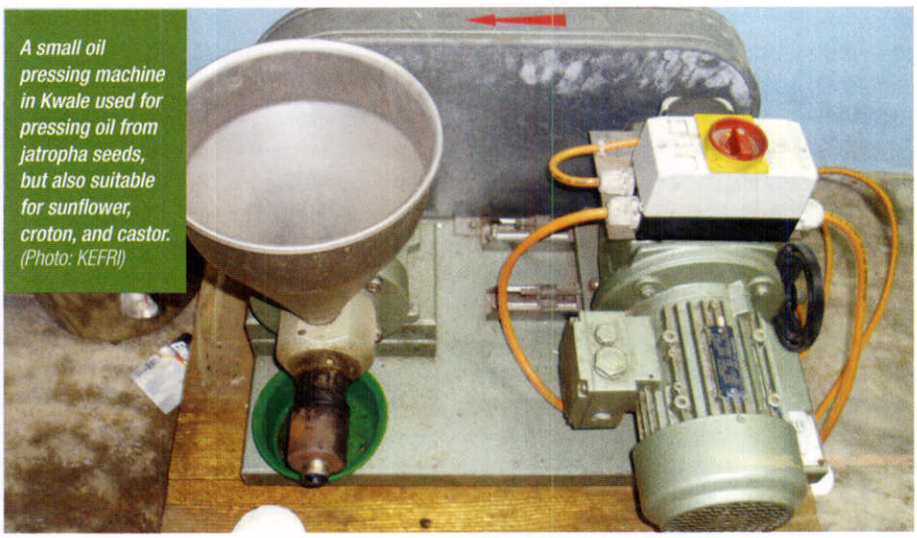
Property	*Croton SVO*	*Jatropha SVO*	*Kenya Diesel Standard*	*Standard specification of diesel*
Density (kg/m^3)	922	916.2	820-870 (@ 20°C)	820-840
Flash Point (°C)	227	213	60°C min	50°C
Viscosity (mm^2/S @ 40°C)	28.8	33.3	1.6-5.5	>2.7
Carbon Residue (% mass)	0.69	0.11	0.15 max	0.15 or less
Iodine Number (g/100g)	142.88	108.57	-	n/a
Sulphur Content (ppm)	400	91	500 max	500 max
Acid Number (mg KOH/g)	2.48	2.10	0.5 max	n/a
Phosphorous (ppm)	300	100	-	n/a
Calorific Value (kJ/kg)	38,510	38,490	-	44,800
Oxidation Stability (hours)	78	62	-	n/a
Ash (% mass)	<0.01	0.02	0.01 max	n/a
Water (% mass)	<0.05	<0.05	0.05 max	n/a
Cloud Point	n/a	n/a	12°C max	n/a
Cetane Number	n/a	51	48 min	>50

Source: Jatropha Reality Check - A field assessment of the agronomic and economic viability of Jatropha and other oilseed crops in Kenya (2008)

Definitions and significance of some of the terms used in Table 1

- The density of vegetable oil and biodiesel is generally about 10 – 15 per cent higher than that of mineral diesel. The results on Table 1 indicate that croton and jatropha SVO satisfy the EN standard in regard to density.
- Flash point is a measure of a fuel's flammability. It is used primarily to determine the safety precautions necessary for transport and storage. Vegetable oil and biodiesel generally have flash points much higher than that of mineral diesel, and thus provide an advantage in terms of safety. The flash point limit under the SVO standard is 220°C, which is 100°C higher than the equivalent limit under the EN biodiesel standard. The jatropha SVO fell slightly below the SVO standard.
- Kinematic viscosity is the speed at which a liquid covers a certain distance, which determines the fluidity of the substance. Viscosity of biofuel is important due to its affect on volume flow and injection spray characteristics. Vegetable oils and biodiesels become less viscous at higher temperatures.

  Viscosity may also affect fuel atomisation, which can lead to larger droplets being injected into the compression chamber and less efficient fuel consumption. Heat and transesterification are two ways of reducing the viscosity of vegetable oil. Another way of reducing viscosity to acceptable levels is to blend biodiesel with mineral diesel. Both croton and jatropha SVO satisfy the SVO standard, but are slightly above the upper limit for biodiesel under the US standard.
- Carbon residue is defined as "the amount of carbonaceous matter left after evaporation and pyrolysis of a fuel sample under specific conditions." A higher carbon residue may lead to unwanted deposits in the compression chamber, injector tips, valves and piston rings. Carbon residues may also lead to coking and soot formation in the exhaust. The croton SVO sample tested contained a carbon residue level above the SVO standard. This may be reduced to below the upper limit in the SVO standard through the use of fuel additives or by converting the SVO into biodiesel.
- Iodine number, or value, shows the amount of unsaturation of the SVO or biodiesel, based on the number of double bonds in the molecular structure. The higher the iodine number, the greater the number of unsaturated fatty acids present in the fuel. The more unsaturated the oil (the higher the iodine number), the more likely it is to polymerise in the heat of the engine. Both croton SVO and biodiesel contain iodine numbers above the upper limit permitted by the EU SVO standard and the EU biodiesel standard.
- High sulphur fuels create more sulphur dioxide and particulate matter, and thus contribute to adverse human health. In most of the world, the allowable sulphur level for biodiesel is consistent with the sulphur limits placed on mineral diesel. Unacceptably high sulphur levels can be reduced with the use of magnesium silicate in the purification process.
- The acid number is the measure of free fatty acids in the fuel, which is the result of both the type of feedstock and the conversion process being used. An incomplete transesterification process may result in a higher acid number. Post-reaction neutralisers can also be used to lower the acid number. High free fatty acid content may cause engine corrosion and thermal instability.
- Phosphorous content results from the type of feedstock and the production process. High levels of phosphorous can act as an abrasive agent and can impact exhaust catalytic systems adversely. Phosphorous can be removed by degumming the oil, which is a common process that uses water or acid to reduce the presence of phospholipids in the oil.



A small oil pressing machine in Kwale used for pressing oil from jatropha seeds, but also suitable for sunflower, croton, and castor. (Photo: KEFRI)

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