Unsuitable for human consumption but with a high oil yield, is pongamia the next big biofuel on the block? Charlotte Niemiec assesses its worth and looks at the companies trialling it in the field

Pongamia: a crop that could produce six times more oil per acre than soyabeans or another 'miracle' crop along the jatropha line destined to disappoint farmers? Pongamia has indisputable advantages over other oilseed crops, but its relative obscurity in the biofuels arena means the crop has had limited testing in the field.

Pongamia oil is derived from the seeds of the *Millettia pinnata* tree, a legume native to tropical and temperate Asia but now strewn across the globe. The plant produces pods, the seeds of which contain approximately 30% oil, but this oil is unsuitable for human consumption as it is toxic and will induce nausea and vomiting; its disagreeable taste and odour is due to bitter flavonoid constituents.

Historically, the oil has been used as a lamp oil, in leather tanning, in soap making and as a lubricant. In the Asia region, it was used in traditional medicine for treating skin and liver disease, but it has recently gained a credible place in modern medicine: studies have shown some potential for biocidal activity against *V. cholerae* and *E.coli*, as well as anti-inflammatory, antinociceptive (reduction in sensitivity to painful stimuli) and antipyretic (reduction in fever) properties.

The plant has a natural defence system against pests – it seems to have no natural predators – spurring research that suggests the oil can be used as a natural insecticide.

Nevertheless, it is as a biofuel that pongamia really comes into its own. Numerous companies are looking to exploit the seed's high oil content and the ARC Center of Excellence for Integrative Legume Research explains that growing pongamia as a biofuel crop provides no direct competition with food crops as it is a non-edible source of fuel, and no direct competition with existing farmland as it can be grown on degraded and marginal land.

Furthermore, the ARC notes, as a legume, it is able to fix its own nitrogen from the soil, minimising the need for added fertilisers and enriching the soil in which it is grown. Pongamia trees are non-invasive and highly resistant to both high and cold temperatures, drought and saline soils.

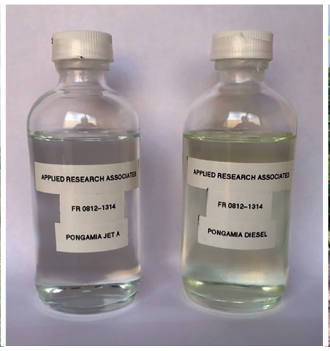
Pods are harvested using existing mechanical shaking equipment – such as that employed in the nut industry – and the oil can be extracted using existing crushing equipment with no modifications. After the oil is extracted, degummed and refined, it can then be shipped to biodiesel producers.

Another end use of pongamia is in the animal feed industry. After the oil is crushed from the seed, the remaining seedcake could be used to feed livestock as the seeds have around a 27% protein content. Phase 1 livestock feed tests on the seedcake have been positive and Phase 2 testing is underway. Furthermore, because of its high nitrogen content, the seedcake could be used as a high nitrogen organic fertiliser; nitrogen is a very expensive crop input and farmers would certainly welcome cheaper fertilisers.

USA, California-based TerViva Bioenergy is one company working with the crop. CEO Naveen Sikka tells *Oils & Fats International* that his company has developed special varieties of pongamia trees that produce between 30-40% oil.

"We're a crop technology company dedicated to pongamia. We see pongamia as 'soyabeans 2.0' – it has a very similar output profile to soyabeans in terms of the lipid and the protein. One of its advantages is that it yields anywhere from three to five times more per acre on output than soyabeans

PHOTOS: TERVIVA BIOENERGY



and it is done with a far better environmental profile – it uses less water, far less fertiliser and it is a perennial crop. However, it's not a miracle crop. It's not going to grow in the deserts of Morocco without any kind of supplemental water."

TerViva focuses on three main areas, Sikka explains – germplasm development, farming and the downstream markets. The company spends a lot of time trying to understand the plant, its biology and how it can be effectively propagated.

"We think that pongamia can be soya-like in its output and palm-like in its yields, with a much better sustainability footprint. In a world where we're looking at shortages of food and an increased use of land for optimisation of food production, we have a real opportunity to make pongamia into something very special."

The company has partnered with biodiesel producers such as the Renewable Energy Group (REG) to make renewable diesel and biofuel from pongamia oil, and it recently completed production of renewable diesel and Jet A using pongamia oil with Applied Research Associates (ARA).

Sikka is enthusiastic about pongamia's potential as a biofuel: "We've successfully made renewable diesel, biodiesel, Jet A – it's a 100% viable biofuel. I think our competitive advantage is that pongamia can yield anywhere from 400 to 1,000 gallons/acre, with a price around the US$30-60/barrel range. Not a lot of crops can make that claim because they're row crops or they're cyclical crops; even jatropha doesn't yield as much because it's a shrub and has to be planted very densely. The drawback, of course, is that it is a tree crop, so it's a long-term gain. It takes four to five years before the first yields can be drawn and it has a 25-year lifecycle, so there are not a lot of places in the world that will have this kind of patience."

Finding the land

Importantly, suitable land must be found upon which to grow the crop and, with agricultural land at a premium, growing crops purely for the purpose of producing biofuels has sparked controversy in recent years.

However, TerViva has a compelling solution: it is repurposing diseased land in Florida, USA, that was home to acre upon acre of citrus groves. A September 2014 article by *AgInvesting* explains: "Few people outside the state of Florida realise that, according to some industry observers, the 150-year-old citrus industry could be on the brink of collapse in as little as two years. The cause is a pinhead-sized insect that transmits a bacterial infection called Huanglongbing (HLB) to citrus trees and slowly chokes off the flow of water and nutrients from the roots to the leaves. Not only have scientists been unable to come up with a viable cure, they haven't even been able to culture it in the lab."

This has devastated the citrus industry in Florida. The report notes: "Citrus contributes US$9bn in revenue to the state and employs 76,000 people. Ten years ago, in its heyday, the state produced around 240M boxes of fruit. As of the most recent USDA report [September 2014], that number has declined to as low as 104M boxes. That rate of decline is not linear, it is accelerating. Estimates are that, as production declines to 80M boxes, most of the remaining processing plants will begin to shut down. After that, citrus in Florida could remain only as a niche crop."

TerViva says that, if there was a viable alternative crop to grow, there wouldn't be over 125,000 acres of abandoned citrus land, and it is looking to capitalise on the devastation left in the region. *AgInvesting* states: "Arguably, the only agricultural industry with deep enough demand to accommodate the tens of thousands of acres of these former citrus properties coming into production is the oilseed industry, where the worldwide demand for oil and protein is huge and growing. Currently, oilseed demand is being met primarily by soya and, to a lesser degree, by cottonseed, canola and other minor (by comparison) row crops like flaxseed and safflower."

TerViva is working with seven of the 10 largest agriculture growers in the state of Florida. It has around 150 acres in the ground across nine different sites.

It is also growing pongamia in Hawaii on abandoned sugarcane lands. Sikka explains that Hawaii has lost around 80% of its sugarcane lands in the past two decades, land that is perfect for pongamia. The company received a US$1M grant from the US Department of Defense for its pongamia project in the state.

A new agricultural model

Formerly known for its development of jatropha varieties, Bosques Energéticos in Mexico has also turned its attention to pongamia. Undeterred by the failure of jatropha to 'make it big' in the biofuel industry, CEO Kirk Haney observes that "it wasn't jatropha that failed, it was the jatropha model that failed." As a result, the company has refined its process and highlights a new, intriguing business model that requires the inter cropping of three different crops.

One of the recognised drawbacks of planting pongamia is the amount of time it takes to reach maturity. Farmers wouldn't expect to see significant returns on their investment for at least five to seven years.

However, Bosques' model maximises both

available land and time by initially planting castor, which sees a quick return on investment within years one to three, inter cropped with jatropha, providing returns in years three to seven, inter cropped again with pongamia, producing significant quantities of oil around the seven-year mark.

Zafar Karim, chairman of Legendary Investments – a London-listed company that invested in Bosques in 2010 – explains why the model works: "If we look at year one and year two, we project 1,200-1,300kg/ha from castor and that's conservative. After year four, pongamia and jatropha kick in. We see jatropha starting at 500kg/ha and getting up to 5,500-6,000kg/ha of seed, with the higher 30% of oil content by year five. With pongamia, we see as much as 3,000kg/ha of seed in year four, 10,000kg/ha of seed by year seven and in the 17,000-18,000kg/ha range by year 10."

Encouragingly, biotechnology might help hasten the process, as Karim notes: "With pongamia, typically you get flowers in year four and seeds in year five. So far as we knew, no one had got flowers in two years, but we are doing that now with our 4G pongamia." The company's 4G jatropha programme succeeded in bringing yield times down from 18 months to under a year.

Sikka also believes biotechnology could increase yields. He explains: "For our planting style and density, we're talking about 50kg/tree of yield at 150 trees/acre to get 400 gallons of oil. We work with pongamia varieties that yield anywhere between 20-250kgs, so we know of trees that produce four to five times that 50kg level. If you try to calibrate it for size, for a plantation model, we do think pongamia's capable of building into the 150kg/tree range, which could push yields to 400-1,200 gallons, just by picking the right varieties and learning how to cultivate them to the maximum yield and success. If you step into genetic modification, the sky's the limit; you could modify the composition of fatty acids in the oil, you could modify the percentage of oil content in the seeds.

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How much oil you get out of an acre is dependent on two things: how many seeds on the tree and the percentage of oil in the seed. Right now, we're averaging around 40% oil in the seeds – although it generally averages around 30% – but, with genetic modification, you could maybe get it to 50%. Now you're talking about a 25% increase in yield/acre, so there is a lot of potential."

Growing in popularity

While pongamia is still relatively unheard of, its popularity is growing. Organisations across the globe, such as The Pongamia Project in Australia, are championing its benefits as a biofuel crop. This project is looking to increase funding for research into pongamia, increase investment in plantations to help create a supply chain that will be operational within five years, to increase the attractiveness of the sector to both investors and companies, and to build general support for pongamia biodiesel.

Sikka concludes: "If we can prove to the market, to the Procter & Gamble's of the world, that we can deliver a large-scale supply of this oil, they will innovate on top of that platform. For example, we use soya oil and palm oil for a myriad of products, because there's a lot of it. That's our strategy – we're taking it step by step. The first step is to get yields successfully demonstrated, to get the right germplasm, to get into a competitive position and then build relationships with downstream players and use it for chemicals, fuel, even food – and see how we can produce a very sustainable product." ●

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