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TOBACCO SEEDS CONTAIN UP TO 40% OIL AND AROUND 1,000 ACRES OF TOBACCO COULD YIELD MORE THAN ONE MILLION GALLONS OF FUEL

A smoking hot biofuel

The race is on to find a suitable feedstock for aviation biofuel. Industry giants such as Boeing, South African Airways and SkyNRG have teamed up to investigate whether tobacco is a good contender. Charlotte Niemiec looks at global research into the crop's potential to produce biofuel and its various other applications

Fuelling aeroplanes is an expensive business; the UK's *Wired* magazine notes that, in 2012, the world's airlines spent US$209bn on fuel – amounting to 33% of operating costs. Not just that, but using traditional fossil fuels such as kerosene to fuel the engines is damaging to the environment. The International Air Transport Association (IATA) estimates that using biofuels instead of fossil fuels could cut the industry's overall carbon footprint by 80%.

However, there's a problem: if the industry were to switch to biofuels now, the costs would skyrocket. Biofuels derived from plants and agricultural wastes that are currently available are more expensive than traditional jet fuel. Nevertheless, it is hoped this will change if and when production is ramped up.

The next problem is feedstock: for all industries trying to move from fossil fuels to biofuels, it is proving tricky to secure a sustainable, efficient, competitively-priced and inexhaustible feedstock. This is particularly trying for an industry such as aviation, where enormous amounts of fuel are required.

But, according to Boeing, South African Airways (SAA) and SkyNRG, a potential – and somewhat surprising – feedstock exists: tobacco. These giants of the airline industry are experimenting with producing biofuel from 'Solaris' tobacco. Boeing announced in August last year that SkyNRG was expanding production of the plant in South Africa as an energy crop that farmers could grow instead of traditional tobacco. According to a Boeing press release: "Test farming of the plant, which is effectively nicotine-free, is underway in South Africa, with biofuel production expected from large and small farms in the next few years." The plan, says Boeing, is to convert oil from the plant's seeds into jet fuel. The company adds: "In coming years, Boeing expects emerging technologies to increase South Africa's aviation biofuel production from the rest of the plant [and not just its seeds]."

This particular type of tobacco was invented and patented by Italian company Sunchem Holding – an industrial research and development company operating in the sectors of genetic and recombinant DNA in plants for energy and human purposes – which owns the exclusive rights to Solaris, or 'seed tobacco'. The company's website explains that the plant has several advantages over other feedstocks: it is extremely robust and is able to grow in various climates and soils. An annual plant, it can be cultivated on marginal lands that cannot be used for food production and can be harvested in the same year of sowing, enabling farmers to plan the amount of land dedicated to Solaris each year. The seeds themselves contain around 40% oil and, after cold pressing, seeds can produce 33-34% of raw oil and 65% protein cake.

A SkyNRG press release adds that, in addition to the production of vegetable oil, the plant can be used to generate valuable animal proteins and biomass for providing electricity to rural environments. The company is concentrating on demonstrating the sustainability of the plant by meeting the criteria of the Roundtable on Sustainable Biomaterials (RSB).

Setting a sustainable example

According to SkyNRG, a Netherlands-based aviation fuels company focused on sustainable fuels, "aviation is one of the most dynamic, economically

crucial and socially essential industries. At the same time, this industry is responsible for up to three percent of global man-made CO_2 emissions. Unlike other forms of transport – such as cars that can switch to alternative energy sources like ethanol, hydrogen or electricity – aviation has fewer green alternatives to significantly reduce its carbon footprint." SkyNRG's mission is to play a pioneering role in creating a sustainable future for aviation. The Netherlands' KLM airline was SkyNRG's launching customer on 23 November 2009, when the airline operated the world's first demonstration test flight with passengers on board using sustainable jet fuel.

Boeing is the aviation industry's leader in the development of sustainable biofuel, working with partners in Australia, Brazil, China, Europe, Japan, the Middle East, South Africa, the USA and other countries. The company says it is encouraged to invest in alternative fuels because, when produced sustainably, the use of aviation biofuels reduces carbon emissions by 50-80%, compared to using petroleum jet fuel. Since aviation biofuels were approved in 2011, over 1,500 passenger flights have been conducted.

SAA has pledged to reduce its carbon emissions by 34% by 2020 and 42% by 2025 – and it wants to use home-grown biofuel by 2017.

The airlines anticipate growing Solaris on a large scale, as well as on smallholder farms in the South African region. The companies are already working together with South African stakeholders to "position farmers with small plots of land to tap markets for biofuel feedstocks that provide socio-economic value to communities without harming food supplies, fresh water or land use." The consortium wants to raise further funding in the near future to reach critical scale as soon as possible, it says.

Global research into tobacco

However, the Solaris tobacco type is not the only tobacco variety – and the Boeing, SAA and SkyNRG consortium is not the only team – producing fuel from tobacco. Researchers from Royal Holloway University of London, UK, were awarded a grant from the European Union (EU) in 2012 after identifying a tobacco tree that could produce biofuels.

Scientists at the university's School of Biological Sciences discovered that *Nicotiana glauca* produces compounds that can be used as a biodiesel, which could be used directly as fuel or cracked to produce petroleum compounds.

Nicotiana glauca is a species of wild tobacco known as 'tree tobacco', native to South America but now widespread on other continents and a common roadside weed in the southwestern USA. Significantly, the plant grows well in warm and arid climates; it does not require fertile ground and can thrive in regions that receive just 200mm/year of rainfall, with temperatures exceeding 40ºC. Initial studies showed the plant was able to grow in desert climate conditions, such as those found in the United Arab Emirates (UAE), North Africa and other arid or tropical regions of the world.

"This is a crucial factor", says Dr Paul Fraser from the university. "It means that growing this crop will not be in competition for land space with food crops. Indeed, many farmers have already raised concerns about giving their land over to biofuel crops. Our discovery could potentially solve this issue."

AS GLOBAL SMOKING PREVALENCE FALLS, PRODUCING BIOFUELS DERIVED FROM TOBACCO PLANTS WOULD OFFER TOBACCO FARMERS MORE SECURITY IN THE FORM OF AN ADDITIONAL END USE FOR THEIR CROPS

Other research has been undertaken by scientists at the Lawrence Berkeley National Lab in California, USA, under a project funded by the Department of Energy (DoE)'s Advanced Research Projects Agency-Energy (ARPA-E), a US government agency tasked with promoting and funding research and development of advanced energy technologies. The scientists again selected tobacco because the plant is "grown in large tracts throughout the USA and in more than 100 countries."

Furthermore, tobacco "generates multiple harvests per year, its large leaves could store a lot of fuel and it is amenable to genetic engineering." Tobacco has huge potential because it produces very high yields, the researchers say, estimating that "about 1,000 acres of tobacco could yield more than one million gallons of fuel".

Currently, they note, tobacco is one of the most ubiquitous plants in the American south. But, as sales of commercial tobacco products fall, demand for the crop is declining. If tobacco were to be redirected to biofuels, it could resuscitate an industry upon which many depend for their livelihoods.

The Tobacco Atlas Organisation notes that, while smokers consumed nearly 5.9 trillion cigarettes in 2009, global smoking prevalence is flat or decreasing (although the total number of smokers worldwide continues to increase simply due to population growth). The organisation suggests that the pattern of nicotine consumption may shift in future, as people seek alternative nicotine delivery systems such as gum or electronic cigarettes.

Cultivating tobacco for biofuels, therefore, makes solid commercial sense, especially as "tobacco grown for biofuel purposes can be planted at up to 16 times the density of tobacco planted for consumption, so fields already producing the plant could vastly increase production to meet potential future need." The Berkeley scientists are working on creating tobacco plants that maximise the uptake of CO_2 and sunlight, and the production of oils and fats.

Furthermore, at Old Dominion University (ODU) in Virginia, USA, Sandeep Kumar, assistant professor of civil and environmental engineering, is conducting research into the areas of biofuel production from non-food-based biomass feedstock. He notes: "We're trying to replace petroleum as much as possible, reduce greenhouse gases and make fuels that can be produced locally."

As the state of Virginia is a huge tobacco producing region, research into alternative uses of the plant here makes sense. Tyton BioSciences, based near Danville, is one of several Virginia companies exploring new uses for tobacco as the smoking rate declines nationwide.

The company notes that tobacco produces a plethora of valuable proteins and chemicals that can be used for a variety of purposes besides smoking products, including applications in the animal feed, pharmaceutical and biofuel industries. ODU and Tyton BioSciences have jointly filed two patent applications in the past year around a chemical-free process of turning the tobacco plant into biofuel.

One patent involves removing the sugars from the tobacco biomass to create a fuel source; the second is to process tobacco seeds themselves to extract an oil product and other fuel products. Tyton BioSciences received a grant from the Virginia Tobacco Commission and awarded US$61,000 to Kumar's team at ODU. The team is testing different tobacco plant varieties and developing novel processes to produce advanced biofuels and bio-products as efficiently as possible.

Finally, Ruth Sanz-Barrio, an agricultural engineer of the NUP/UPNA-Public University of Navarre in Pamplona, Spain – and researcher at the Institute of Biotechnology – says her research shows that "the leaves of genetically modified tobacco plants were releasing 500% more fermentable sugars. With these sugars, which could later be turned into bioethanol, one could obtain up to 400 litres/tonne of bioethanol from fresh leaves ... which would mean an almost 10-fold increase in bioethanol yield with respect to the control tobacco plant that had not been modified."

She concludes that genetically-enhanced tobacco could be an alternative source of biomass in areas such as Extremadura and Andalusia in Spain, the traditional tobacco producers.

"The estimated calculations of the starch production of these enhanced varieties would be equivalent to those of crops such as barley or wheat", she says, adding: "As cereals are currently being used as the raw material to produce bioethanol, genetically-enhanced tobacco could be an alternative source of biomass and for obtaining clean energies." ●

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