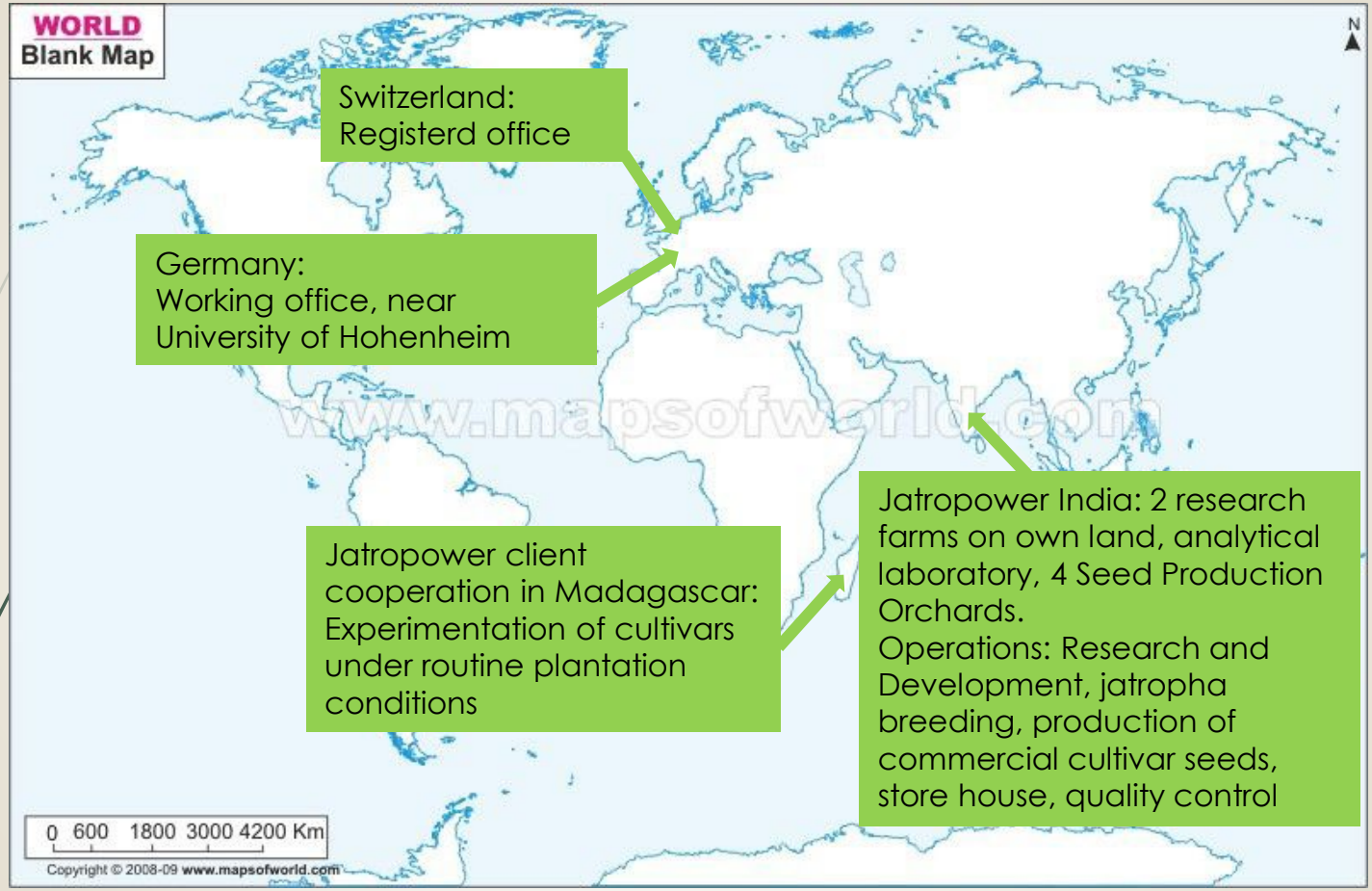
JATRO POWER

Bio-Oil Production along with Carbon Sequestration and Storage with Jatropha curcas plus

Slide 2

Jatropower AG - footprint

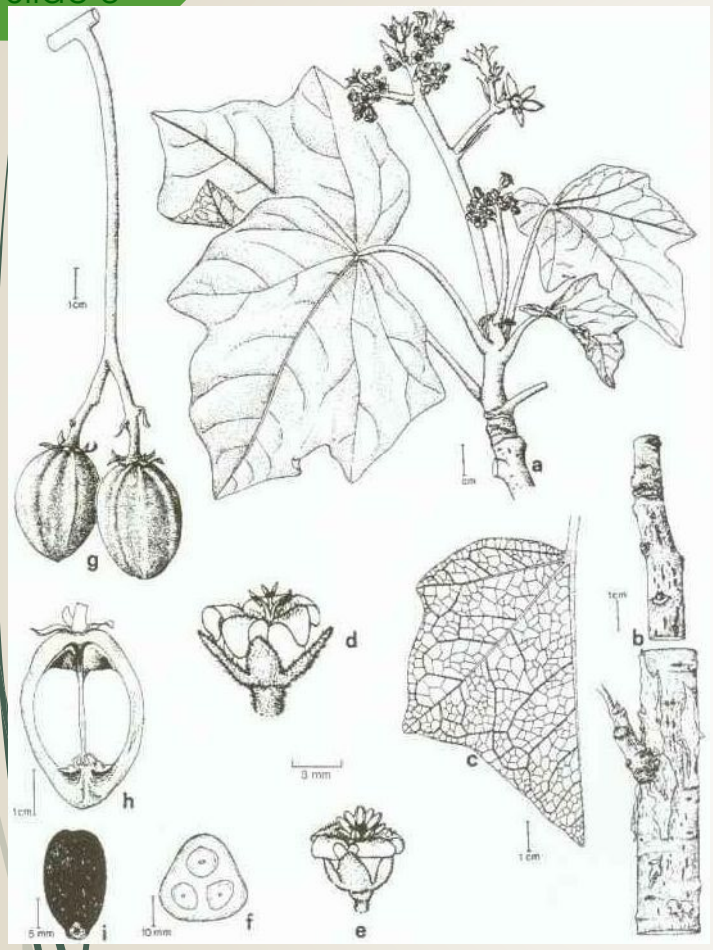


Starting year: 2008, key personnel in jatropha sector since >20 years
Financing: private equity of the promoters
Facilities: Own research farms and laboratory, collaborative research on client farms,
Research collaboration: Public universities and research institutes in Germany, Italy and India

Jatropha curcas - botany

JATRO POWER

Slide 3



a - a flowering branch, b – bark, c – leaf veinature, d – pistillate flower, e - staminate flower, f – cut through immature fruit, g – fruits, h – longitudinal cuts of fruits, i - seed

Family: Euphorbiaceae

Perennial shrub – grows to about 5-6m height

Common name – Physic nut, purging nut

Fruit weighs about 2g (60% seeds and 40% pericarp

Origin: Mexico and Central America (??)

Occurs in tropical America, Africa and Asia

JATRO POWER

Why Jatropha curcas?

- Jatropha seeds contain more than 35% oil that is a suitable feedstock for biodiesel and hydrotreated vegetable oils (HVOs)
- There is an edible variety of jatropha, named Xuta, which can produce multi-purpose oil and food/feed protein
- Perennial plant yielding for more than 20 years after plantation
- Adaptable plant that uses soil nutrients and water efficiently
- Can grow on eroded, nutrient poor land and improve the quality of soils over time
- Seeds easy to harvest, store and process
- High potential for carbon sequestration, especially when planted on denuded land

JATRO POWER

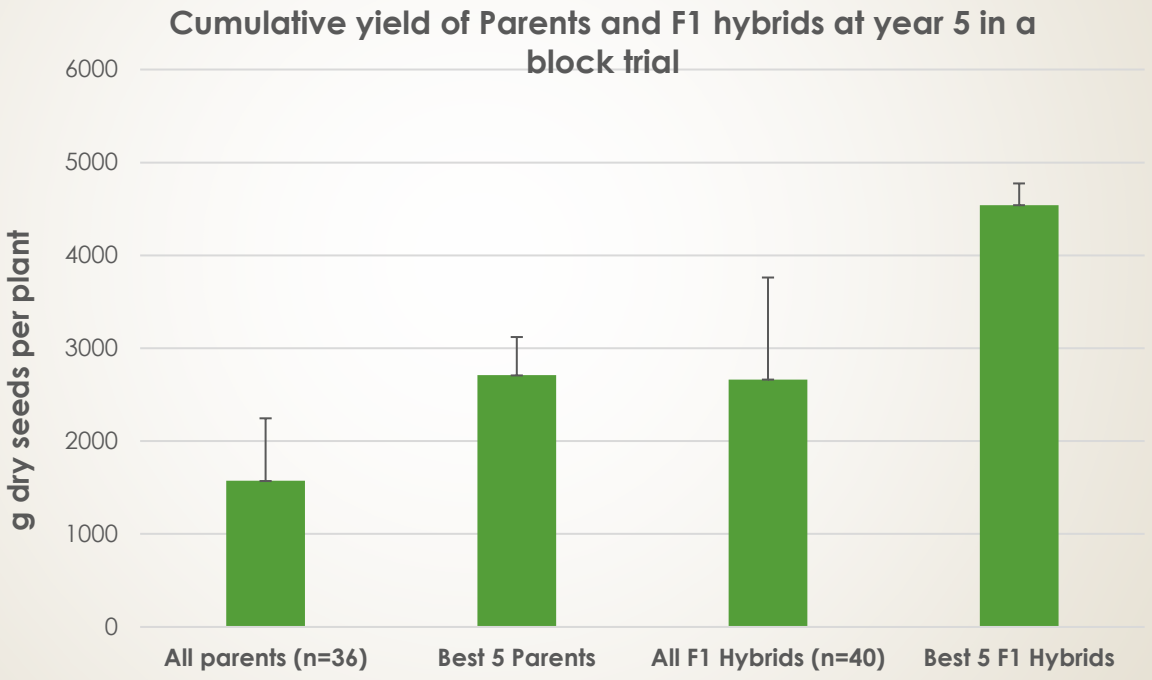
Two main Jatropha curcas lines are under development

- Jatropower is developing two varieties of jatropha parallelly
  - The conventional toxic variety named jatropha– main product is oil as a biofuel feedstock and by-product is seed cake as fertilizer
  - A new edible edible variety of jatropha named Xuta – the products are:
    - Seed oil for use as multipurpose oil, like rapeseed and soy oil
    - Seed kernel meal as human food and animal feed ingredient
    - Seed shells as biomass burning fuel
    - This variety occurs naturally in Mexico and Jatropower has improved it by selection and breeding
  - The difference between the Xuta and jatropha is the absence of the toxic factor, **phorbol esters** in the former.

Slide 6

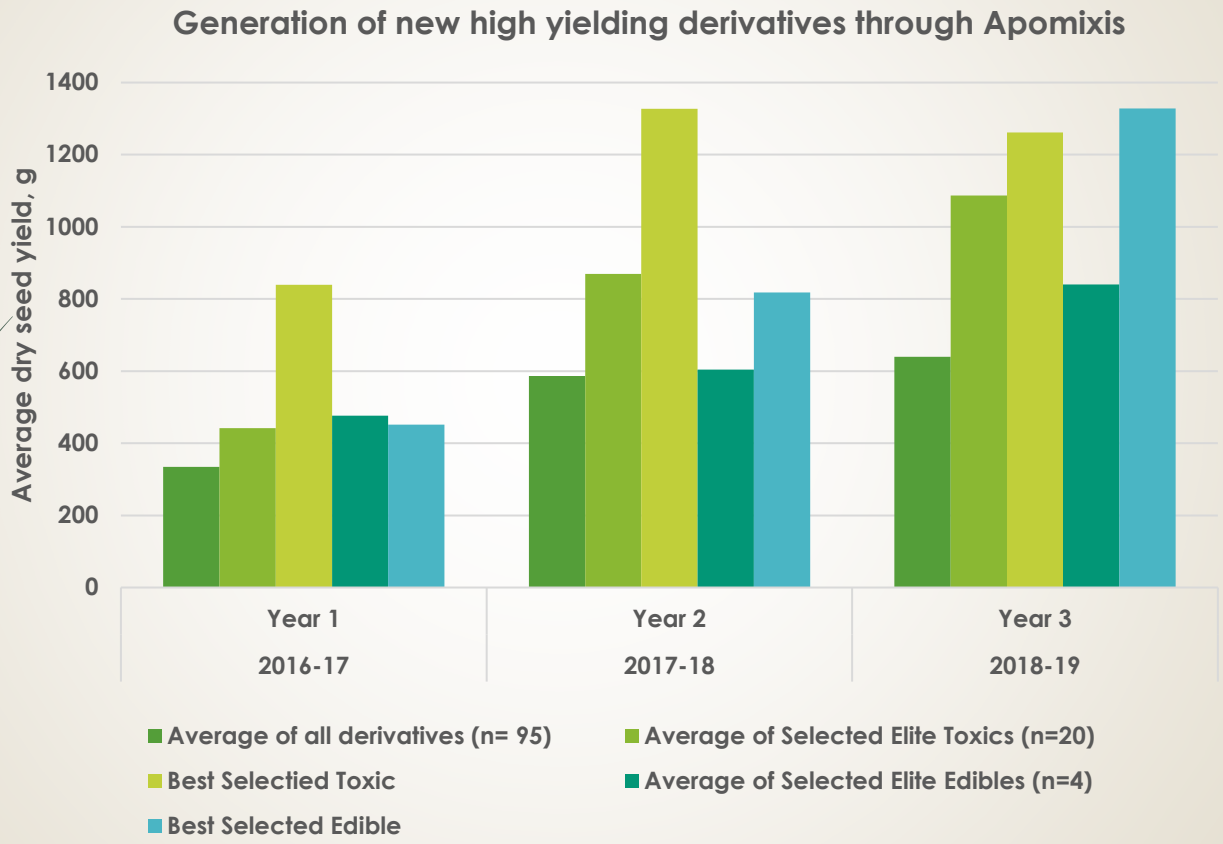
Breeding process and progress – seed yield improvements

Key tools employed: Monitoring, selection and hybridisation



Semi-arid climate and degraded soil framework under which these yields have been obtained: Rainfall: average below 400 mm p.a., soil texture: stony, pH: 8.2, Soil fertility: deficient in N and P and micronutrients such as B and Fe, Soil depth: 30 cm, Irrigation: 14 litres every 14 days during rain-free months

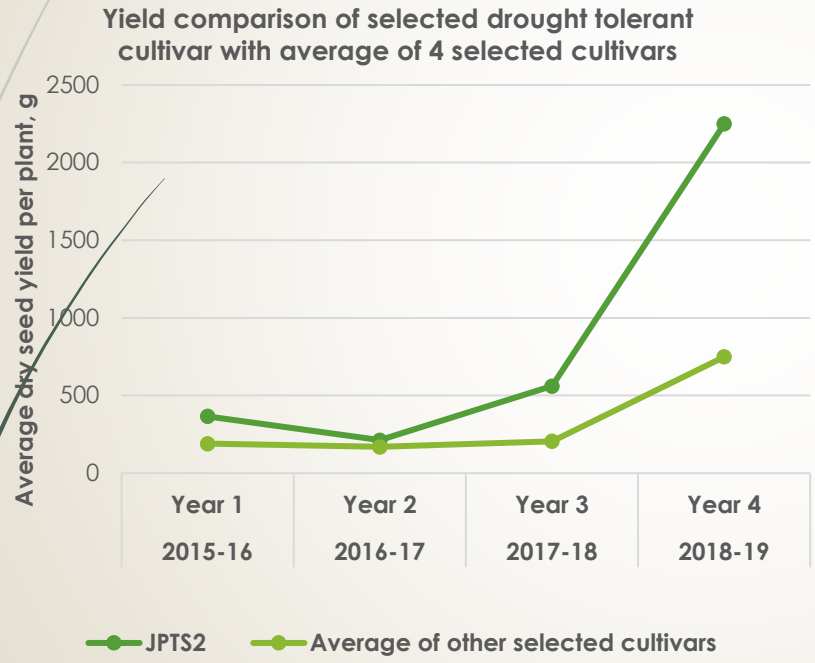
Breeding process and progress – increasing genetic variability



Semi-arid climate and degraded soil framework under which these yields have been obtained: Rainfall: average below 400 mm p.a., soil texture: stony, pH: 8.2, Soil fertility: deficient in N and P and micronutrients such as B and Fe, Soil depth: 30 cm, Irrigation: 14 litres every 14 days during rain-free months

Other breeding goals and tools

Drought resistance



Irregular rainfall and even more frequent droughts are increasing in the jatropha growing areas due to climate change

Deployment of pistillates for scaling F1 hybrid seed production

Pistillate J curcas with only female flowers, Jatropower has developed the non-edible and edible pistillate jatropha plants

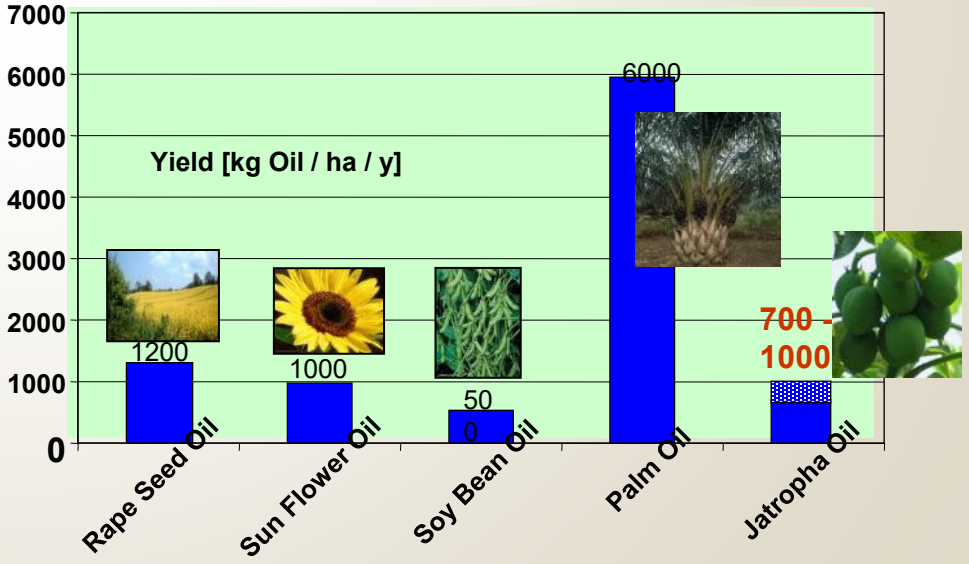
JATRO POWER

Which seed yields are realistic on sub-optimal land?

- Jatropha yield is determined by genetics and agronomy in equal share
- The land available for cultivation is usually not suitable for other crops
- On such land with limiting conditions, with good management, around 2.5 tonnes of seeds per ha per y (750kg oil) per ha per year would be possible with the current breeds

- Under better agronomic conditions, better yield will be possible with the current breeds, with some reports pointing to >4 tonnes of seeds per ha per year.

Jatropha compares well with established oil crops

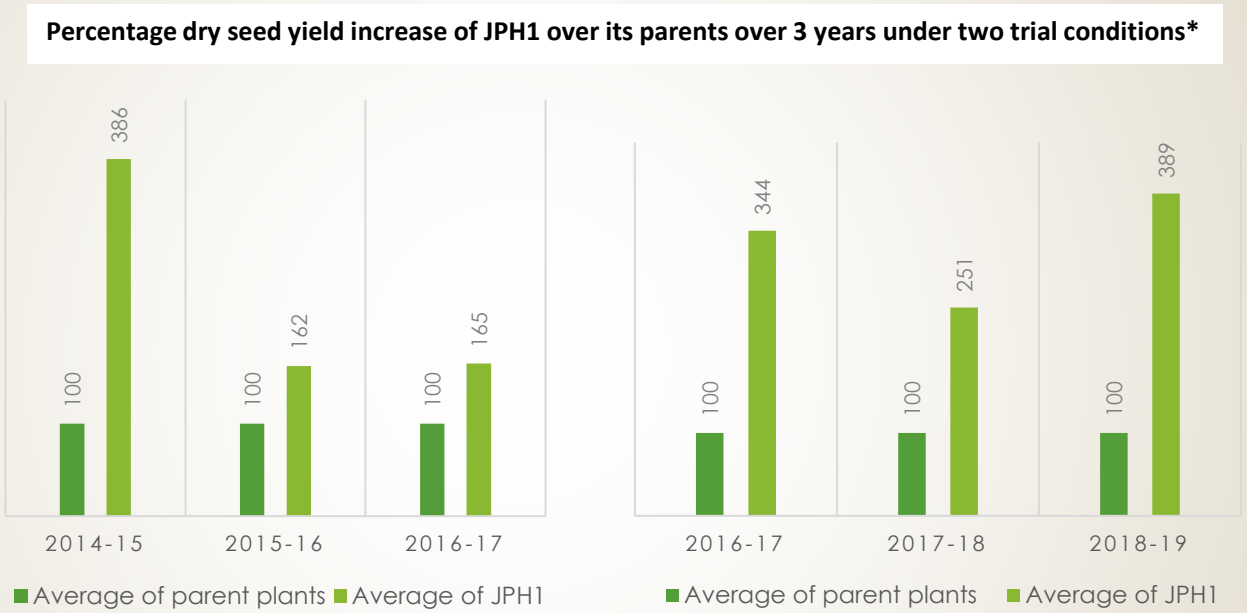


JATRO POWER

JP F1 hybrid **JPH1**, early and profuse fruiting

JATRO POWER

The F1 hybrids perform better also under stressful climatic conditions



** 2015-16, 16-17 and 17-18 were extreme drought years at both the sites in S. India where the trials were conducted.*

JATRO POWER

Jatropower‘s JPNT-1, world‘s first commercial Xuta cultivar

JATRO POWER

Jatropha/Xuta fruit and proportion of its fractions

Dry Fruits 100 %

Seeds 60 %

Husk 40 %

Kernels 65 %

Shell 35 %

Oil 60 %

Kernel meal 40 %

JATRO POWER

Composition of Jatropha/Xuta fractions

	Husk	Shell	Meal	Cake	Oil
Dry matter (%)	91	90	90-95	90.5	
Water content (%)	9	10	5-10	9.5	
Gross energy MJ/kg (on dry matter basis)	15.5	18	18	19.5	39.5
Crude protein (% in DM)	6	4	57.5	23	
Lignin (% in DM)	14.5	45	0.5	22.9	
Hemicellulose plus cellulose (% in DM)	51.5	40	9	23.9	
Total carbohydrates (cellulose + hemicellulose + starch and soluble sugars; % in DM)	51.5	40	26.5	31.2	
Ash content (%DM)	15 - 16	4 - 6	10		

JATRO POWER

Jatropha/Xuta oil is suitable for conversion to renewable diesel/aviation spirit

Physical/chemical properties of Jatropha/Xuta seed oil

Calorific value	37.8 MJ/kg
Appearance	Light yellow liquid
Specific gravity at 30°/30°	0.92
Acid value	1.24
Saponification value	197
Iodine value	102
Unsaponifiable matter	0.4%

Main fatty acids in Jatropha/Xuta seed oil

Oleic acid (18:1)	36-42%
Linoleic acid (18:2)	36-43.5%
Palmitic acid (16:0)	11.6-12.6%
Stearic acid (18:0)	6.5-8%

Slide 16

Xuta kernel meal have been shown to be of high nutritional quality

Ingredients	Proximate Composition in g per kg dry matter				Most limiting essential Amino Acids in g per 100 g protein				
	Crude Protein	Lipids	Ash	Gross Energy (MJ)	Lysine	Methione	Cystine	Isoleucine	Tryptophan
Fishmeal	635	88	142	21,1	6,44	2,52	0,68	3,54	0,77
Soybean meal	471	11,7	22,6	18,2	6,18	1,32	1,38	4,16	1,36
Defatted Kernel Meal of Jatropower	624	12,1	91	18,3	3,45	1,58	1,70	3,97	1,07
Reference protein 2-5-year-old children according to FAO	-	-	-	-	5,80	2,50*	-	2,80	1,10

* including Cystine

There are several refereed publications that have shown the high nutritional quality of Xuta oil and kernel protein in a range of test animals.

JATRO POWER

Use of the whole seed cake of jatropha

- **Bio fertilizer cum bio pesticide**
  - Contains 5.7–6.5% N, 2.6–3.0% P2O5, 0.9–1.0% K2O, 0.6–0.7% CaO and 1.3–1.4% MgO
  - The phorbol esters contained acts as a pesticide against harmful soil organisms
  - There is proof that the jatropha phorbol esters are completely destroyed within 6 days once applied in the soil
  - Our own trials have clearly shown fertilizer and soil improvement value of jatropha whole seed cake
  - Jatropha seed cake has high demand for fertilizer purposes in India in our experience
- **As a substrate for production of biogas**

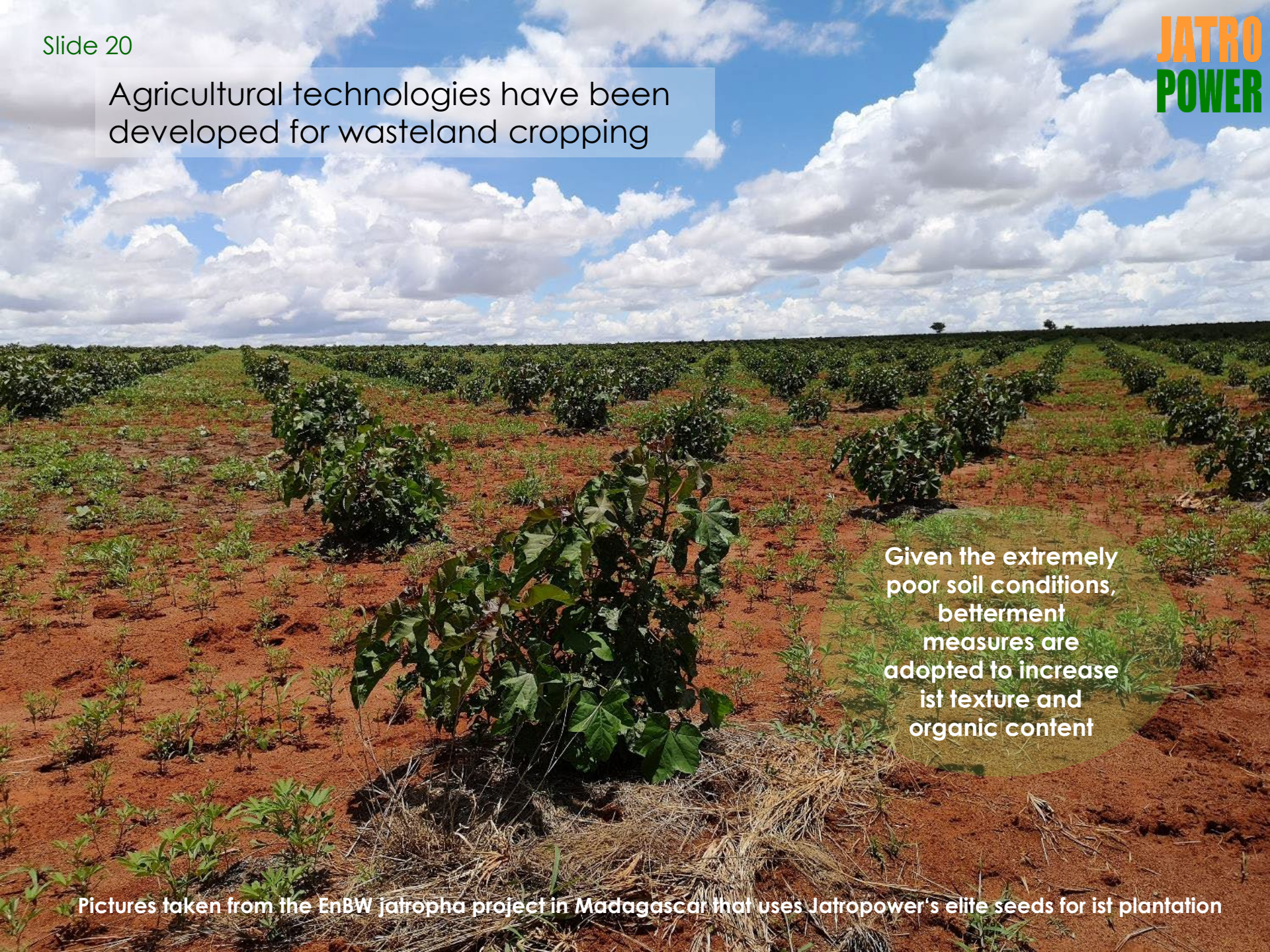
Jatropha plantations on wasteland established using Jatropower's elite seeds

Pictures taken from the EnBW jatropha project in Madagascar that uses Jatropower's elite seeds for its plantation on denuded wasteland

JATRO POWER

Pictures taken from the EnBW jatropha project in Madagascar that uses Jatropower's elite seeds

Agricultural technologies have been developed for wasteland cropping



Given the extremely poor soil conditions, betterment measures are adopted to increase ist texture and organic content

Pictures taken from the EnBW jatropha project in Madagascar that uses Jatropower's elite seeds for ist plantation

Agricultural technologies have been developed for wasteland cropping

JATRO POWER
info@jatropower.ch
www.jatropower.ch

The leguminous intercrops and cover crops help the jatropha plants and to reclaim the soil eventually

Pictures taken from the EnBW jatropha project in Madagascar that uses Jatropower's elite seeds

JATRO POWER

The plants establish well and develops good standing biomass in quick time under sub-optimal conditions

18 month old edible jatropha cultivar cultivar JPNT1 on wasteland in Madagascar

A first assessment of the CO2 credit generation potential made for the Madagascar jatropha project

JATRO POWER

- The project is eligible under Gold Standard (GS) and Verra (VCS) platforms as a CO2 sequestration project to obtain Voluntary Emission Reduction (VER) credits
- Under the GS requirements, the crediting period shall cover at least 30 years
- A net CO2 sequestration of 4.8 tonnes per hectare and year was assessed based on the biomass growth on the ground, after substracting baseline C under the project-site conditions and the 20% risk margin required by GS
- The VERs generated has good demand, given the quality of the project and the high UN-SDG impacts, especially SDGs 3, 5, 6, 7 and 13.
- Negotiations under the Paris agreement and its eventual acceptance will result in still higher demand (and prices) for the VERs

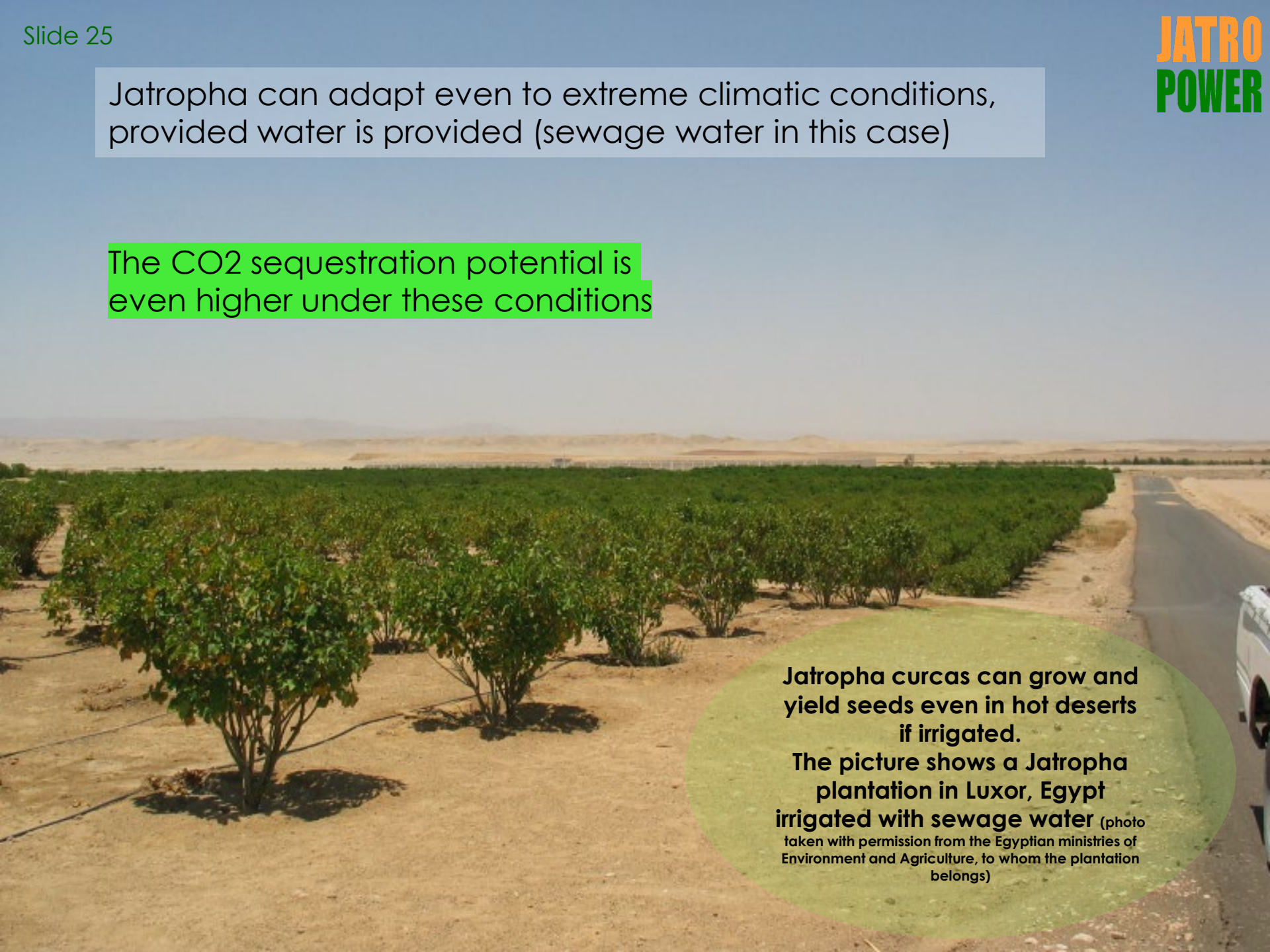
Experience of partner, Jatrosolutions Cameroun in the Sahel zone

Pictures from Ossere Faouro, Garoua, land on the desert edge before planting (left) and 2 years after planting J. curcas (right)
Pictures credit: Dr Euloge Dongmeza

JATRO POWER

Jatropha can adapt even to extreme climatic conditions, provided water is provided (sewage water in this case)

The CO_2 sequestration potential is even higher under these conditions



Jatropha curcas can grow and yield seeds even in hot deserts if irrigated.
The picture shows a Jatropha plantation in Luxor, Egypt irrigated with sewage water (photo taken with permission from the Egyptian ministries of Environment and Agriculture, to whom the plantation belongs)

Subsidiary crops in portfolio that offer diversification options in/around jatropha plantations

JATRO POWER

Moringa oleifera Lam.

- Has come to be known as a "Miracle tree"
- Quick growing and drought tolerant
- Short-duration and perennial crops possible
- Separate "pod varieties" and "leaf varieties" are under development
  - Moringa pods are a much loved vegetable in S India, the mature seed oil is a very quality cosmetic ingredient
  - Moringa leaves have a protein content of 23-25% in dry matter, high protein quality
- Higher leaf and pod yields compared to existing varieties
- High CO2 sequestration potential, depending on cultivation model

JATRO POWER

Proposed addition: Sweet Sorghum

- C4 crop with low input requirements and accumulates high levels of sugars in its stalks.
- Drought tolerant
- Grains can be used as a gluten-free substitute of wheat or corn flour.
- Sugar-rich stem juice can be used for ethanol production
- By-products used as biomass feedstock for various purposes
- 1 t/ha grain yield plus >4 tons of ethanol yield per ha per 115 day crop

Thank you for your attention

JATROPOWER AG
Haldenstrasse 5
CH-6340 Baar, Switzerland

Contact:
Dr. George Francis, CEO
Tel: +49 711 94542744
E-mail: info [at] jatropower.ch

More information at www.jatropower.ch

JATRO POWER

Additional information

JATRO POWER

Products and services

- Jatropower maintains a diverse jatropha genotype collection that represents the global genetic diversity of the species available in all jatropha hotspots in the world
- The company's main products are its elite jatropha seeds. Two main lines of jatropha seeds are under development
  - Conventional jatropha elite seeds to facilitate production of new generation fuel and industrial feedstock production
  - Edible jatropha varieties for edible vegetable oil and plant proteins from less optimal soil conditions
- Site assessment for suitability of jatropha cultivation
- Cultivation techniques for efficient agronomic management of jatropha plantations
- Robust processing techniques for edible and non-edible jatropha seeds
- Subsidiary crops to increase crop diversity when desired by customers

Jatropha curcas seeds in portfolio

JATRO POWER

- Jatropower has several elite jatropha cultivars and hybrids currently in its portfolio
- Details can be obtained from:
  - Non-Edible High Performance Jatropha – Elite cultivars - Jatro Power
  - Non-Edible High Performance Jatropha – F1 Hybrids - Jatro Power
  - Edible High Performance Jatropha - Jatro Power

- Jatropower's proposed climate solution "**Jatropha F1 Hybrid Seeds for New Generation Fuel Production**" has been one of the early selections to the elite "**1000 Solutions to protect the environment**" of the Solar Impulse Foundation, Switzerland. More details at https://solarimpulse.com/efficient-solutions/jph1-seeds
- The same solution has been selected as one among 5 climate solutions (out of over 360 solutions) by the International Finance Corporation (IFC) for pitching to global investors

JATRO POWER

Seed production capabilities

- Selection, hybridisation and testing on own research farms
- Testing also on client projects, with their consent
- JP operates 5 isolated seed production farms at its station in India for commercial seed production
- Scaling up of production facilities based on demand possible
- Experience in supplying seeds and technology, mainly to clients in India and diverse African countries

JATRO POWER

Other Jatropha species available at the farm for crossing trials

- Jatropha gossypifolia
- Jatropha mahafalensis
- Jatropha glandulifera
- Jatropha integerrima
- Jatropha pandurifolia
- Jatropha platyphylla

JATRO POWER

Publication list

1. Francis, G., Makkar, H.P.S., Carle, R. et al. Critique on conclusions regarding toxic compounds in Jatropha curcas kernel cake. Nature Commun Biol 4, 1348 (2021). https://doi.org/10.1038/s42003-021-02869-6
2. Francis, G., Kerem, Z., Makkar, H., & Becker, K. (2021). Reflections on 'The biological action of saponins in animal systems: A review'. British Journal of Nutrition, 1-3. doi:10.1017/S0007114521004852.
3. George Francis, John Oliver, Piergiorgio Stevanato, Sujatha Mulpuri (2020) Apomixis as a tool for development of high yielding clones and selections in Jatropha curcas L. Genetic Resources and Crop Evolution Vol. 67, 3, 727-743. https://doi.org/10.1007/s10722-019-00851-0.
4. Daniele Trebbi, Samathmika Ravi, Chiara Broccanello, Claudia Chiodi, George Francis, John Oliver, Sujatha Mulpuri, Subhashini Srinivasan & Piergiorgio Stevanato (2019) Identification and validation of SNP markers linked to seed toxicity in Jatropha curcas L. Nature - Scientific Reports (2019) 9:10220, https://www.nature.com/articles/s41598-019-46698-4.
5. George Francis (2019) Economic feasibility and sustainability of Jatropha as a crop, In: M. Sujatha, B. Bahadur, N Carels (eds), *Jatropha, Challenges for a New Energy Crop - Volume 3: A Sustainable Multipurpose Crop*, Springer Nature Singapore Pte Ltd, 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore.
6. George Francis (2018) Non-toxic Jatropha promises to shake up the fuel vs food debate. Biofuels International, July/August 2018, 22-23.
7. George Francis, John Oliver, Sujatha Mulpuri (2017) High yielding and trait specific genotypes and genetic associations among yield and yield contributing traits in Jatropha curcas L. Agroforestry Systems 2017, 1–20. https://doi.org/10.1007/s10457-017-0089-2
8. George Francis (2016) Jatropha – A second Chance. Biofuels International, July/August 2016, 42-43.
9. Daniele Trebbi, Mulpuri Sujatha, John Oliver and George Francis (2016) Edible jatropha: Identification of SNPs linked to non-toxicity trait. Poster on non-toxic marker at presented at PAG XXIV, 9-13 January, SanDiego; California, USA.
10. M. Sujatha, M. Tarakeswari, G. Francis (2013) Start codon targeted (SCoT) polymorphism in toxic and non-toxic accessions of Jatropha curcas L and development of a codominant SCAR marker. Plant Science 207, 117–127. http://www.sciencedirect.com/science/article/pii/S0168945213000447
11. Nithiyanantham, S., Siddhuraju, P., and Francis, G. (2013) A promising approach to enhance the total phenolic content and antioxidant activity of raw and processed Jatropha curcas L. kernel meal extracts. Industrial Crops and Products, 43, 261-269. http://www.sciencedirect.com/science/article/pii/S0926669012004153
12. George Francis, John Oliver, Mulpuri Sujatha (2013) Non-toxic jatropha plants as a potential multipurpose multi-use oilseed crop. Industrial Crops and Products 42, 397–401. http://www.sciencedirect.com/science/article/pii/S0926669012003378
13. Nithiyanantham, S., Siddhuraju, P., and Francis, G. (2012) Potential of Jatropha curcas as a biofuel, animal feed and health products. Journal of the American Oil Chemists' Society, 89, 961-972. http://link.springer.com/article/10.1007%2Fs11746-012-2012-3
14. George Francis (2012) Jatropha seeds, oil and by-products: important properties with respect to uses. In: M. Sujatha, B. Bahadur, N Carels (eds), *Jatropha curcas*, Scientific Publishers (USA)
15. J. Martı´nez-Herrera, J. Martinez, A. M. Ayala, R. M. Escobedo, L. G. Siciliano, G. Da´vila-Orti´z, C. Chamorro, H.P.S. Makkar, G. Francis, K. Becker(2012) Evaluation of the nutritional quality of non-toxic kernel flour from jatropha curcas L. In rats. Journal of Food Quality 35, (2) 152–158. http://onlinelibrary.wiley.com/doi/10.1111/j.1745-4557.2011.00432.x/abstract
16. Jorge Martinez Herrera, Alma L. Martinez Ayala, Harinder Makkar, George Francis, Klaus Becker (2010) Agroclimatic conditions, chemical and nutritional characterization of different provenances of *Jatropha curcas* L from Mexico., European Journal of Scientific Research 39 No.3 pp.396-407. http://www.cibatlaxcala.ipn.mx/docs/articulos/5_2010_abstract_ciba_ipn.pdf
17. Meng Ye, Caiyan Li, George Francis and Harinder P. S. Makkar, (2009) Current situation and prospects of *Jatropha curcas* as a multipurpose tree in China. Agroforestry Systems 76, 2, 487-497. http://link.springer.com/article/10.1007%2Fs10457-009-9226-x
18. Basha, S.D., Francis, G., Makkar, H.P.S., Becker, K., Sujatha, M (2009) A comparative study of biochemical traits and molecular markers for assessment of genetic relationships between Jatropha curcas L. germplasm from different countries. Plant Sci. 176, 812-823. http://www.sciencedirect.com/science/article/pii/S0168945209000934
19. Harinder PS Makkar, George Francis and Klaus Becker (2008) Protein concentrate from Jatropha curcas screw-pressed seed cake and toxic and antinutritional factors in protein concentrate. J Sci Food Agric 88, 1542–1548. http://onlinelibrary.wiley.com/doi/10.1002/jsfa.3248/abstract
20. Goel G, Makkar HPS, Francis G and Becker K (2007) Phorbol esters: structure, biological activity, and toxicity in animals. Int J Toxicol 26, 279–288. https://ec.europa.eu/research/agriculture/pdf/events/phorbol_ester.pdf
21. J. Martı´nez-Herrera, P. Siddhuraju, G. Francis, G. Da´vila-Orti´z, K. Becker (2006) Chemical composition, toxic/antimetabolic constituents, and effects of different treatments on their levels, in four provenances of Jatropha curcas L. seeds from Mexico. Food Chemistry 96, 80–89. http://www.sciencedirect.com/science/article/pii/S0308814605001603
22. George Francis, Raphael Edinger and Klaus Becker (2005) A concept for simultaneous wasteland reclamation, fuel production, and socio-economic development in degraded areas in India. Need, potential and perspectives of Jatropha plantations. Natural Resources Forum 29, 12–24. http://cat.inist.fr/?aModele=afficheN&cpsidt=16598495