

Cite this presentation as:

Jongschaap, R.E.E., L.R. Montes Osorio, F.J. de Ruijter, E.N. van Loo, 2010. [Highlights of the *Jatropha curcas* Evaluation Program \(JEP\): crop management and the fate of press-cake and other by-products with its effects on environmental sustainability.](#) International conference on *Jatropha curcas* 2010. ICJC2010, 1-2 November 2010, Groningen, The Netherlands.



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Highlights of the *Jatropha curcas* Evaluation Program (JEP) 2006-2010

**Crop management and the fate of press-cake and other by-products
with its effects on environmental sustainability**

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International Congress on *Jatropha curcas* (ICJC2010)
Groningen, 1-2 November 2010



Introduction

- *Jatropha curcas* Evaluation Program
- Claims and Facts
- Marginal lands and jatropha
- Dry matter and productivity
- The bio-refinery concept and sustainability
- Dry matter removal scenarios



Jatropha curcas Evaluation Program (2006-2010)

- Investigate claims
- Collect and characterize
 - Genetic resources
 - Passport data
- Genotype x Environment
- Identify and Map traits for future breeding
 - Ranking differs!
- www.jatropha.wur.nl

Genetically ~~Identified~~ ~~Original~~ ~~Populations~~ of Jatropha in

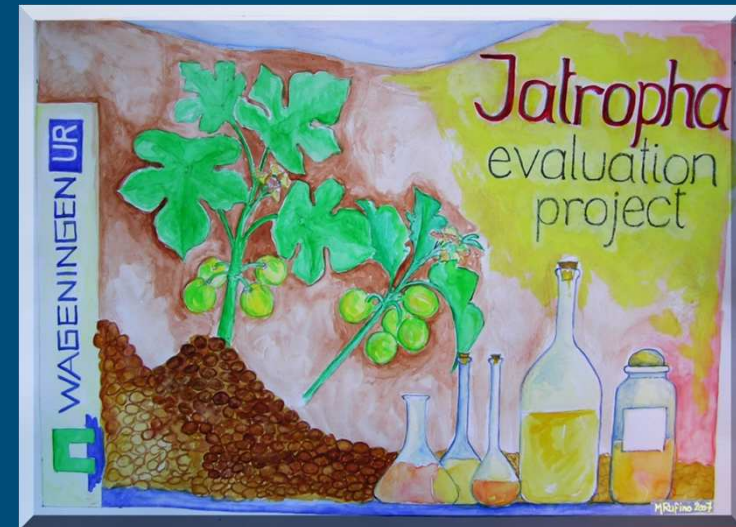
Refined (original soils)

Plants (Only) ~~data~~

Genetically ~~Identified~~ ~~Original~~ ~~Populations~~ of Jatropha in

Tropical ~~populations~~ ~~of~~ ~~diseases~~

Toxicity



Claims: Crop requirements are low

Jatropha curcas

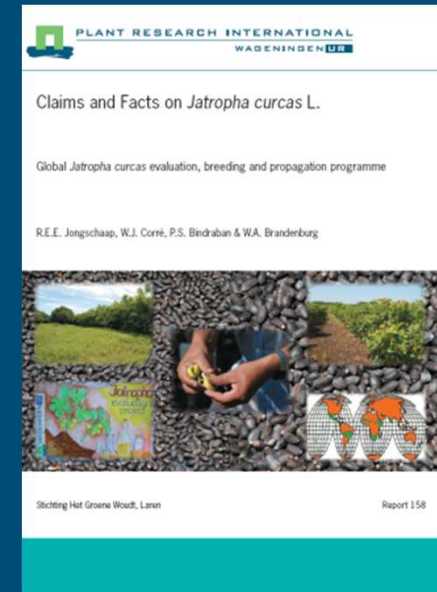
- has low nutrient requirements
- grows well under saline conditions
- is drought tolerant
- has low water use (high water use efficiency)
- is tolerant or resistant to pests and diseases

Claims



Conclusions 'Claims and Facts on *J. curcas* L.'

- Claims are **correct** for **traditional use**
 - Inputs and requirements
 - Environmental effects
- Claims are **incorrect** for **high oil production**
 - Inputs and requirements (water, fertility, labor)
 - Pest and diseases (mono-crop, plantations)
 - Yield components



Marginal lands

- What are marginal lands, why are they marginal?
- How do they look like?
- Where are they?
- Whose are they?

→ Reasons for marginality should be identified and quantified!



Marginal lands

- Since 1945 extent of soil degradation by human activity:
2 Billion ha (= $2 \cdot 10^9$ ha = 2,000,000,000 ha) \approx 17% Earth surface
- \approx 750 M ha (38%)
 - **lightly degraded** (small decline in agricultural production, potential to recover)
- \approx 910 M ha (46%)
 - **moderately degraded** (great reduction in agricultural productivity; restoration only through considerable financial and technical investment);
- \approx 300 M ha (15%)
 - **severely degraded** (no agricultural utility under local management systems; reclaimable only with major international assistance)
- \approx 9 M ha (0.5%)
 - **extremely degraded** (incapable of supporting agriculture and not reclaimable).



Jatropha curcas marginal land reclamation

- Perennial
 - Use as re-forestation species in remote areas
 - Cropping system design
- Drought tolerant
 - Survives dry years
- Deep roots
 - Soil exploration for water and nutrients (recycling)
 - Senescent root material as Organic Matter in soil profile
- Canopy covers soil
 - Anti-erosion

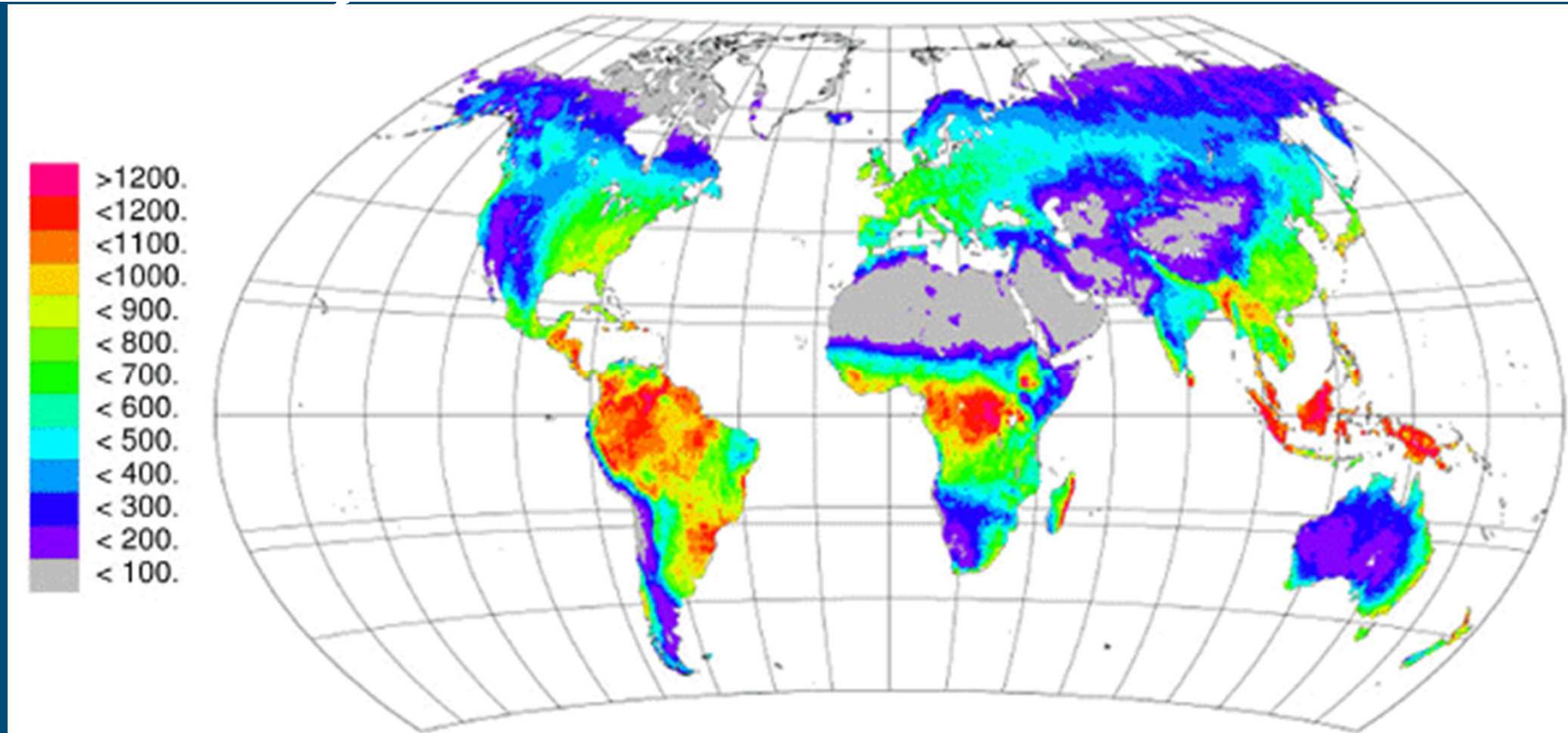


Facts of soil improvement by *Jatropha curcas*

- Increase of soil aggregate size
- Increase in soil organic matter content
- Decrease of soil bulk density



Potential yield estimation method



Annual net primary production (NPP, $g\ C\ m^{-2}\ y^{-1}$) estimated by different simulation models (Sahagian & Hibbard, 1997).

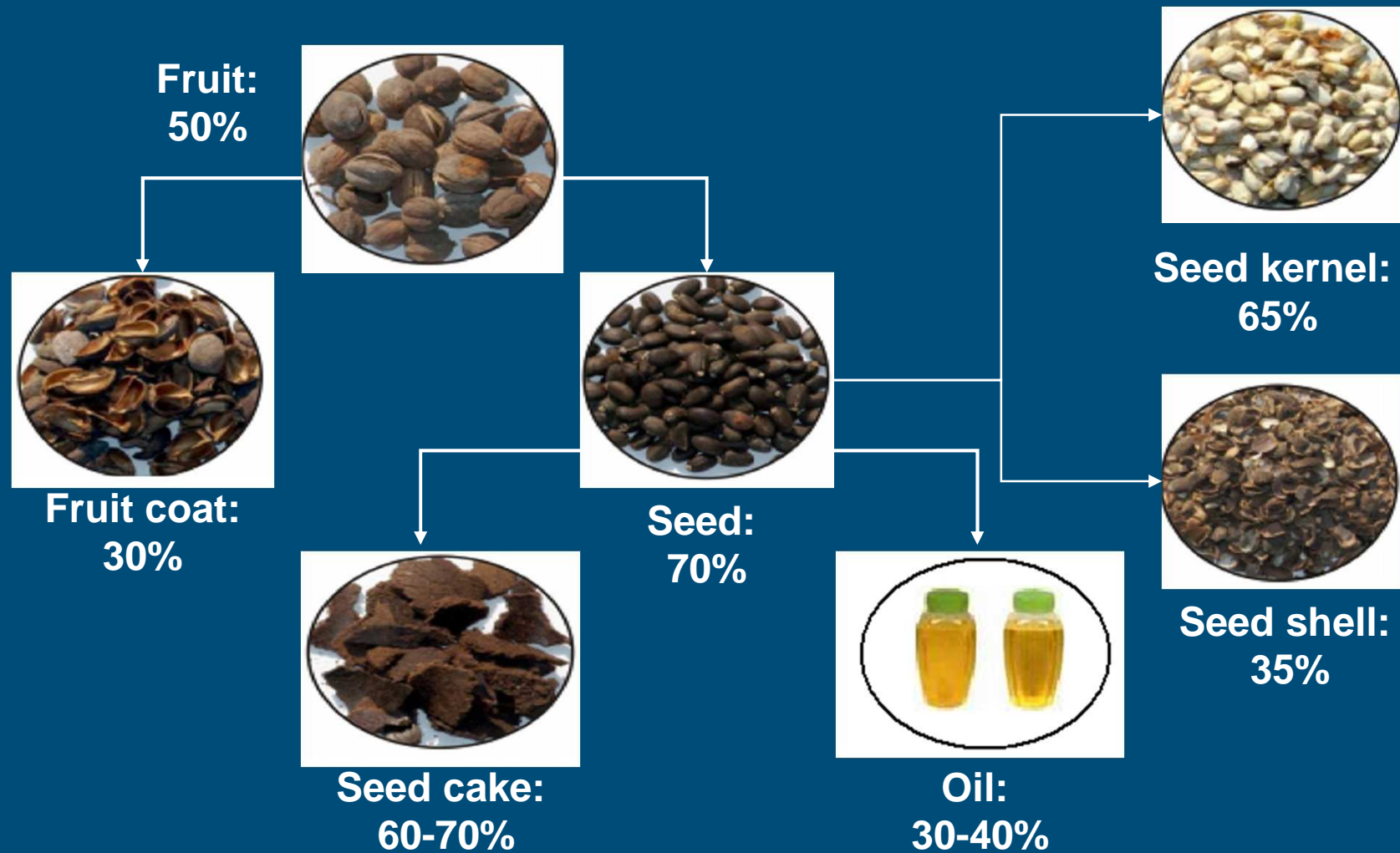
('Claims and Facts on *Jatropha curcas* L.' available at www.jatropha.wur.nl)



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Sahagian, D. L. and K. Hibbard, 1997. GAIM The first five years: Setting the stage for synthesis, IGBP/GAIM Report Series, Report 6, 76 pp.

Dry matter distribution



Potential yield estimation method (continued)

- **MAX** 1000 g C m⁻² y⁻¹ equals 10 ton C ha⁻¹ y⁻¹
- 47.5% C in dry matter: 22.2 t dry matter ha⁻¹ y⁻¹
- 25% leaves, 25% stems: 50% fruits: 11.1 t ha⁻¹ y⁻¹
- 70% seed in fruit: 7.77 t seed ha⁻¹ y⁻¹
- 35% seed oil content: 2720 kg oil ha⁻¹ y⁻¹
- 75% pressing efficiency : 2040 kg oil ha⁻¹ y⁻¹
- 0.92 kg oil liter⁻¹ → 2220 liter oil ha⁻¹ y⁻¹



Resources: crop growth limitations

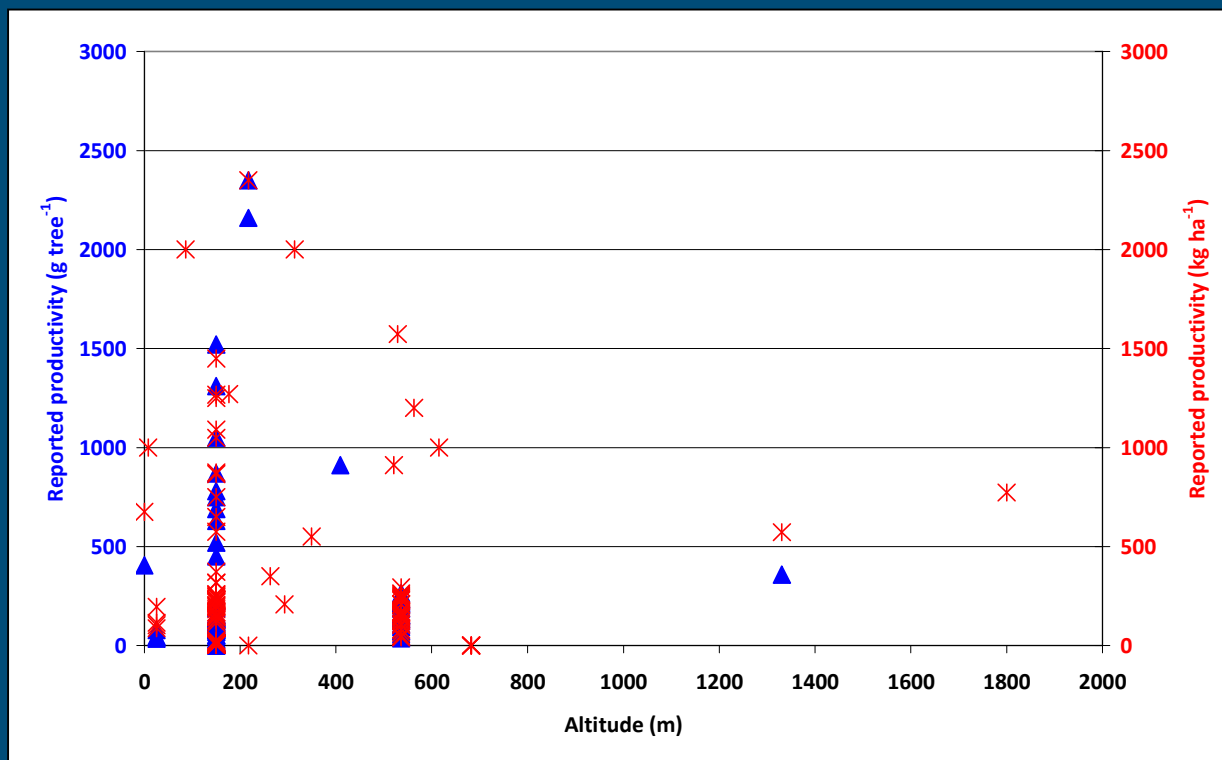


- water + water - water + water
- nutrients - nutrients + nutrients + nutrients

- No such thing as plants growing without water, nutrients, CO₂, land, ...
- Low input – low growth – low yield?
- Competing Claims on natural resources
HUGE!



Jatropha productivity

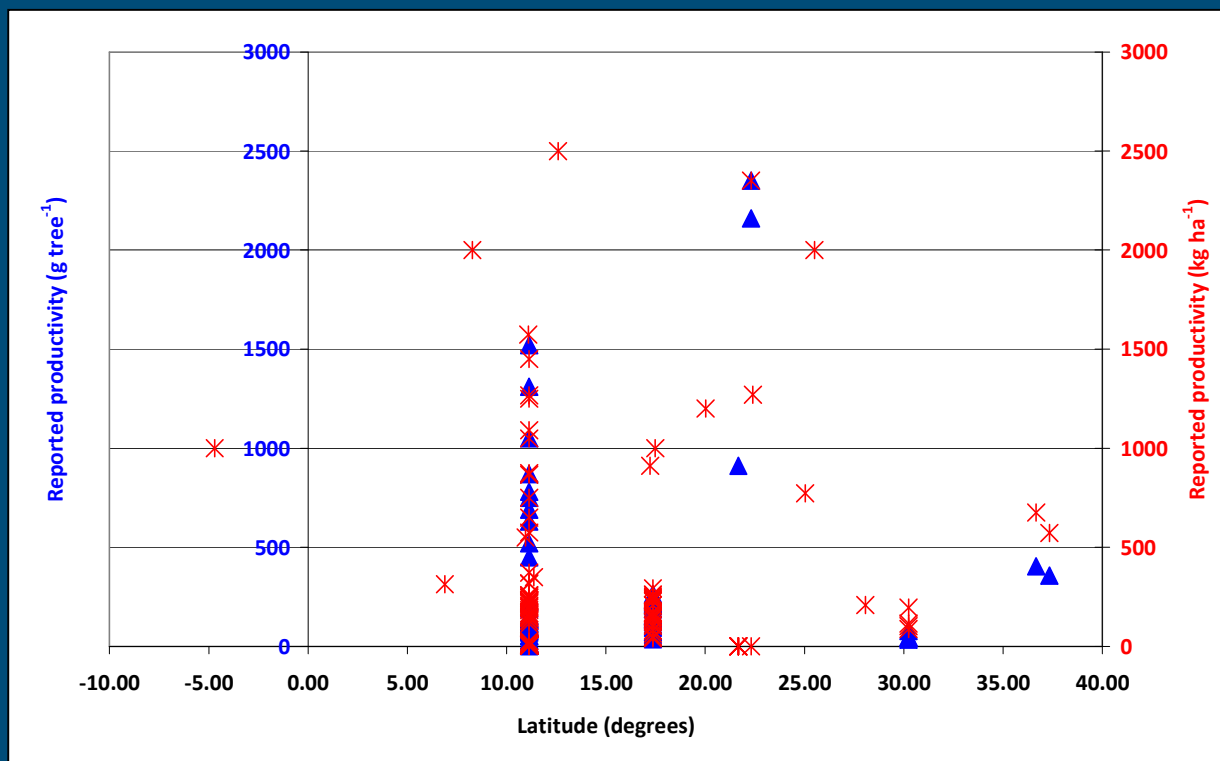


Reported jatropha productivity on a 'per tree basis' (blue triangles; g tree⁻¹) and 'per unit area basis' (red asteroids; kg ha⁻¹), in dependence of altitude (m).

Eijk, J. van., E. Smeets, R.E.E. Jongschaap, H. Romijn, A. Balkema, 2010 (in press). Jatropha Assessment. Agronomic, Social, Economic and Technical aspects. Facts from literature. AgentschapNL, Utrecht, the Netherlands, 150 pp.



Jatropha productivity



Dry matter fraction and nutrient concentration

- Seasonal dry matter distribution
 - Available resources: a.o. soil fertility status
 - Plant age and competition effects

	DMF	N	P	K
	(-)	(%)	(%)	(%)
Roots	0.08	2.2%	0.1%	2.2%
Stems	0.23	3.3%	0.1%	2.9%
Leaves	0.23	5.0%	0.2%	2.0%
Fruit coat	0.14	0.9%	0.1%	3.3%
Seed shell	0.11	0.4%	0.0%	0.5%
Seed kernel	0.21	2.5%	0.5%	1.0%
Sum	1.00			



Dry Matter Distribution in Mozambique

Field ID	Stem [%]	Branches first year [%]	Branches second year [%]	Petioles [%]	Leaves [%]
Bilibiza I	15,24	28,40	34,63	4,83	16,91
Bilibiza II	9,57	16,17	42,70	7,05	24,51
25 Setembro	22,54	32,16	30,52	4,24	10,54
1º Maio I	18,94	42,20	27,35	1,79	9,71
1º Maio II	15,18	41,22	23,35	3,55	16,69
Ngeue	18,95	45,25	26,95	1,27	7,58

- DM distribution does not differ significantly within fields
- DM significantly differs between fields for petioles and leaves
- Fields with pruned plants present higher percentage of DM in branches from the second year, petioles and leaves

Albéniz, J., M. Slingerland, R.E.E. Jongschaap, 2010. Jatropha development explained by soil nutrient status. ICJC, 1-2 November 2010, Groningen, the Netherlands



Oil and by-products

- Only elements C, H and O (from CO₂ sequestration and H₂O use) are removed with the oil
- Removing press-cake from the jatropha system depletes soil fertility, which should be replenished by fertilizer applications
- By-products (bio-refinery concept) from press-cake, pruning wood and leaves put an additional claim on soil fertility: **sustainability is at stake**



Scenarios

- Dry Matter Removal 1 (DMR1)
 - Remove 25% pruning wood
 - Remove 100% fruits (fruit coat, seed hulls, oil and press-cake)

- Dry Matter Removal 2 (DMR2)
 - Remove 50% of seed hulls
 - Remove 50% of seed kernel (=oil)
 - Return press-cake and leave pruned wood in the field

→ **Consequences on nutrient requirements?**



Nutrient removal at different seed productivity levels

			Seed productivity level (kg ha ⁻¹)		
DMR1			500	1000	1500
Removed (kg ha ⁻¹) & req nutrients	N		15	30	45
	P		2	4	6
	K		15	30	45
DMR2			500	1000	1500
Removed (kg ha ⁻¹) & req nutrients	N		1	1	2
	P		0	0	0
	K		1	2	3
Difference DMR1-DMR2			500	1000	1500
Removed (kg ha ⁻¹) & req nutrients	N		14	28	43
	P		2	4	6
	K		14	28	42



Fertilizer requirements at different seed productivity levels

		Min. Fert. recovery	Seed productivity level (kg ha ⁻¹)		
DMR1			500	1000	1500
Removed (kg ha ⁻¹) & req fertilizer	N	50%	30	60	90
	P	10%	20	41	61
	K	40%	38	75	113
DMR2			500	1000	1500
Removed (kg ha ⁻¹) & req fertilizer	N	50%	1	3	4
	P	10%	0	1	1
	K	40%	2	5	7
Difference DMR1-DMR2			500	1000	1500
Removed (kg ha ⁻¹) & req fertilizer	N	50%	28	57	85
	P	10%	20	40	60
	K	40%	35	71	106



Conclusions

- Dry Matter Assignment
 - Investigate variation in DMA based on genotype and environmental factors
 - Research on increasing Harvest Index
- Bio-refinery concept affects fertilization requirements



Financed by Stichting Het Groene Woudt, The Netherlands

Thank you very much – Questions?

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