

A to Z of *Jatropha curcas* L.

3. Agronomy

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June 9, 2008



Outline

- *Jatropha curcas* plant requirements
- Optimization of agronomy aspects
 - Soil conditions
 - Irrigation
 - Nutrient management
 - Pest & disease management
 - Intercropping
 - Pruning & flower induction

Agronomy

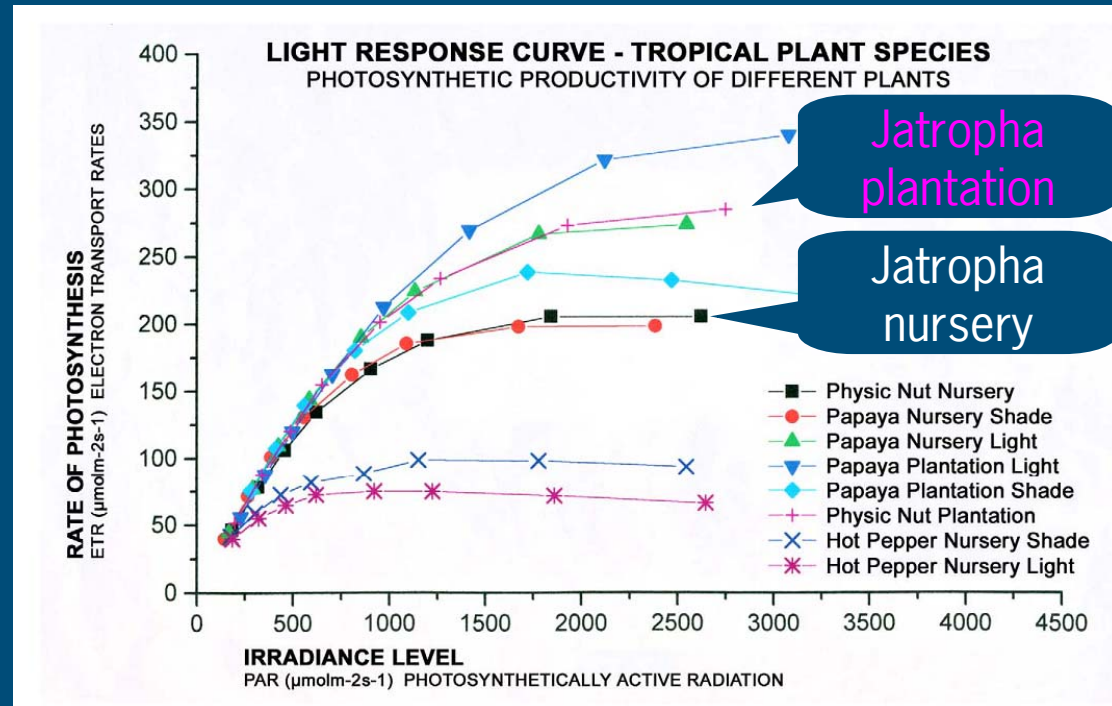
■ Optimization

- Plant growth
- Crop growth
- Cropping system
- Farming system



Optimization

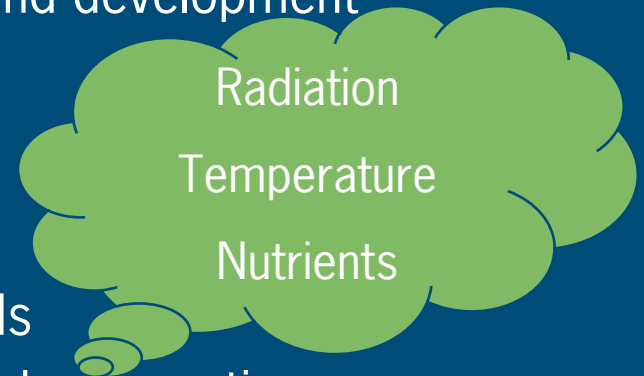
- Plant requirements
- Growth conditions
 - Radiation
 - Temperature
 - Water availability
 - Soil fertility



Baumgart (2007) in cooperation with Tree Physiology department Albert-Ludwigs University Freiburg, Germany.

Plant preferences and/or requirements

- Growing season
 - At least 3-4 months with adequate growth conditions to secure crop growth, flowering and ripening of seeds
- Temperature
 - High(er) temperatures favour plant growth and development
 - No frost
- Rainfall / Water requirements
 - 200-300 mm y-1 to survive
 - 500-600 mm y-1 to produce fruits and seeds
 - Pro-longed water supply results in pro-longed and continuous seed formation



Plant preferences and/or requirements

■ Drought period

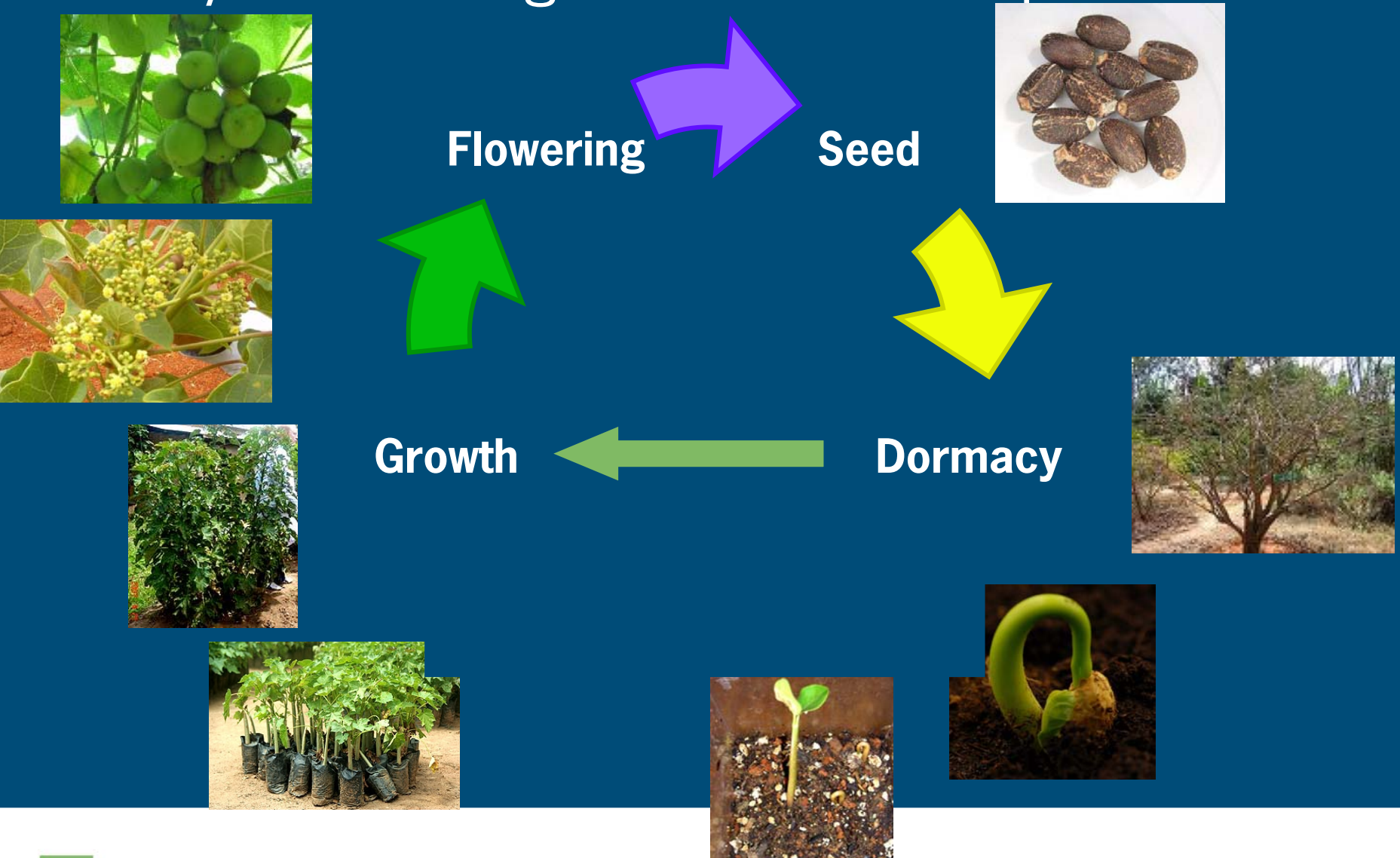
- \approx 1 month needed for dormancy stage
- Flower induction by 1st rains or irrigation

■ Soils

No (heavy) clay soils

- No water-logging! Problems occur already after 2 days!
- Preference for well-aerated soils (texture, aggregates)
- Sufficient water holding capacity for water supply
- $6 < \text{pH (acidity)} < 8$
- Soil fertility (O.M., macro- (NPK) and micro-nutrients) favors crop growth and development

Jatropha curcas growth and development



Aim of agronomy measures

- Basic plants requirements
- Agronomy measures to optimize use of resources during plant growth
- May be different per growth stage



Natural resources and inputs

- Restrictions and boundaries that reduce crop growth
 - Limited natural resources (growth period)
 - Radiation
 - Temperature
 - Water
 - Soil fertility
 - Limited inputs (€ / US\$)
 - Labour
 - Fertilizer
 - Irrigation

Basics of crop production

Growth & yield defining factors

- Weather
- Crop genetic potential



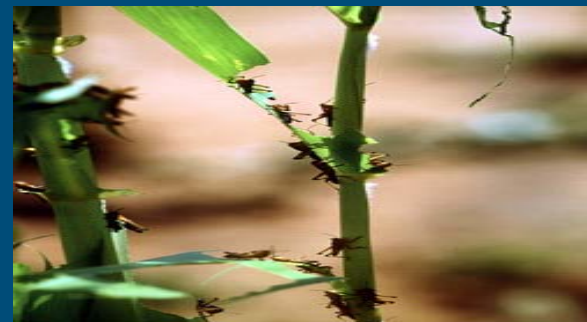
Growth & yield limiting factors

- Water
- Nutrients



Growth & yield reducing factors

- Weeds
- Pests
- Diseases



Genetic resources

Constraints / Threats

Growth & yield defining factors

- Low yielding ability
- Susceptibility to pests and diseases
- Erosion of genetic material



Opportunities / Interventions

- Gene bank management
- In vitro conservation
- In situ conservation
- Crop diversification
- Restoration of natural habitat

Growth & yield limiting factors

- *Integrated Nutrient Management*

Growth & yield reducing factors

- *Integrated Pest Management*



Soil-water

Constraints / Threats

Growth & yield defining factors

Growth & yield limiting factors

- Low soil fertility, Erosion
- Salinity, Alkalinity, Acidity, Toxicity, ...
- Drought and poor rainfall distribution
- Excess water

Growth & yield reducing factors

Opportunities / Interventions

- Tolerant crops
- High use efficiency

- Crop - livestock
- Cereal - legume
- Agroforestry
- Conservation techniques
- Small scale irrigation

- *Increase soil flora and fauna*
 - *Worms*
 - *etc...*



Weeds-pests-diseases

Constraints / Threats

Opportunities / Interventions

Growth & yield defining factors

Growth & yield limiting factors

Growth & yield reducing factors

- Yield reduction due to
 - Weeds
 - Diseases
 - Pests

- Plant resistance
- Fast canopy closure
- Cultural practices
 - Crop rotation
 - Crop mixtures
- Control measures
 - Biological
 - Chemical
 - Physical



Applicability to farming systems – Opportunities in intercropping

Growth & yield defining factors

- Faster canopy closure → increased light interception
- RUE sole cereal crop = RUE cereal crop in intercropping
- RUE legumes intercropping > RUE sole cropping

Growth & yield limiting factors

- Intercrops take up 40% more P (-4 to 83%) and K (-10 to 87%) than sole crops
- Water capture intercrops = sole crops (-6% - +7%)
- WUE intercropping >> sole crops (18-99%)
 - larger portion of ET captured for transpiration
 - favorable micro climate of shading and vapor pressure for shorter crop

Growth & yield reducing factors

- Fast ground cover reduces weed infestation
- Mixed cropping reduces pest and disease incidence

Intercropping *Jatropha curcas*:

Integrate Food and Fuel production



- Increase Radiation Use Efficiency
 - Light interception
- Increase Nutrient Use Efficiency
 - Micro-climate
 - Avoid nutrient leaching
 - Recycling of nutrients
- Decrease pressure
 - Weeds
 - Pests and diseases
 - Erosion

Risks



Overall

Yield ha⁻¹



Optimizing yield

- Plant architecture

- Yield per m²



- Resources

- Abortion 60% if insufficient radiation, water and nutrients (Kumar & Kumari, 2007)

Crop growth limitations

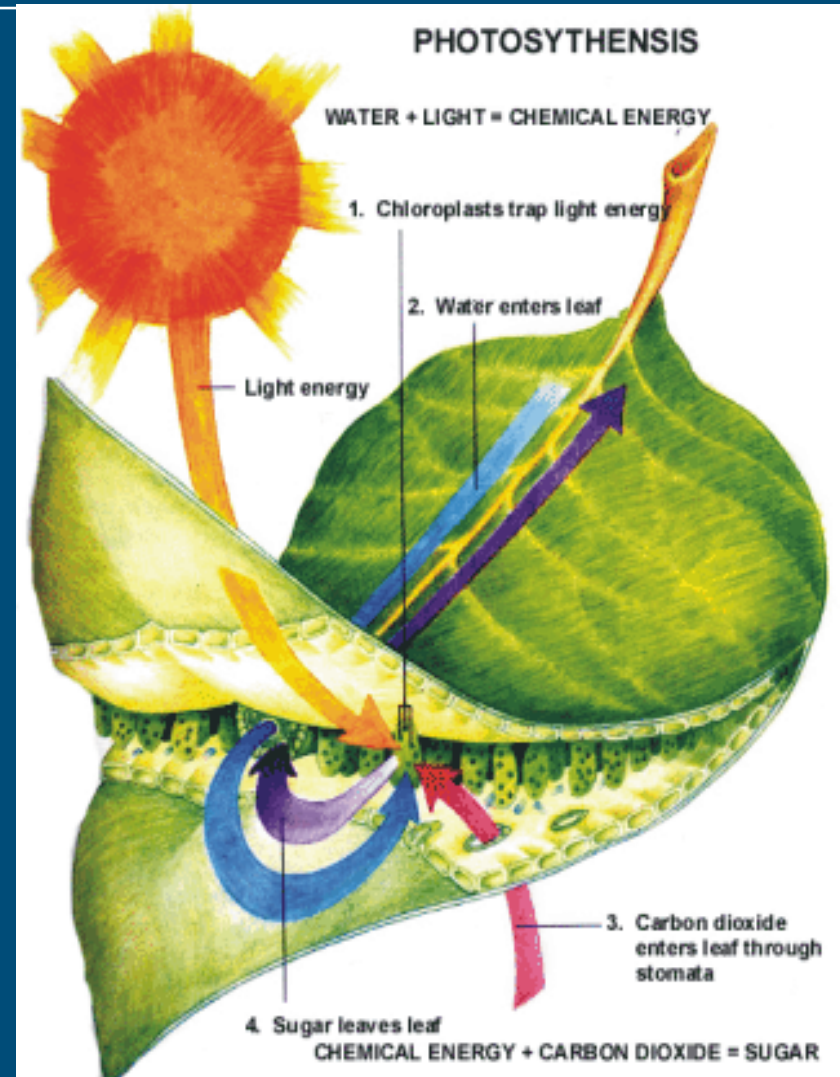


- water + water - water + water
- nutrients - nutrients + nutrients + nutrients

- No such thing as plants growing without
 - Water
 - Nutrients
 - CO₂
 - Land
 - ...Care!
- Low input – low yield

Nutrient requirements

- Nutrients needed for plant growth
 - Macro-elements
 - Nitrogen
 - Phosphate
 - Potassium
 - Spore-elements
- Nitrogen in chlorophyll responsible for photosynthesis process



Source: www.caribbeanedu.com

Nutrient concentrations

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)	B (ppm)	Na (ppm)	Source	
Wood	3.34	0.09	2.87	0.30	0.26	0.12	55	99	2	605	10	134	[3]	
Root	2.16	0.08	2.18	0.18	0.26	0.12	36	251	2	456	13	282	[1,3]	
Leaves	6.40	0.34	2.45	1.40	0.53	0.19	28	168	6	117	71	808	[6] ²	
	4.70	0.15	3.77	0.61	0.49	0.25	25	225	17	211	140	400	[1,3]	
	1.23	0.33	2.17	5.04	1.19	0.13	15	245	7	119	23	398	[6] ³	
	1.83	0.19	0.90	3.66	2.02	0.12	9	226	5	39			[4] ¹	
Fruit	2.15	0.05	0.73	0.44	0.30	0.10	22	40	11	25	4	28	[3]	
	Coat	0.86	0.051	4.23									[4]	
Seed	0.19	0.041	2.35	0.18	0.06	0.03	4	31	2	35	6	142	[3]	
		0.31											[2]	
Shell	0.70	0.047	1.58										[4]	
	0.19	0.01	0.31	0.28	0.06	0.01	1	8	3	13	2	20	[3]	
	Kernel	4.39	1.10	0.94	0.34	0.53	0.21	47	73	18	28	5	17	[1]
		1.96	0.49	0.42	0.15	0.24	0.09	21	33	8	13	2	8	
		2.53	0.37	1.25										[4]
Seed cake	3.82	1.75	1.44										[2]	
	4.90	0.90	1.75	0.31	0.68	0.24	55	772	22	85	20		[3]	
	6.40	2.80	0.95	0.65	1.35								[5]	



Dry matter

Percentage

Relative distribution between organs

Wood, Leaves, Fruit

	Moisture (%)	Dry Matter (%)	Relative composition (%)	Oil content (%)	Source
Wood	15	85	25		Openshaw, 2000
Leaves			25		Openshaw, 2000
Fruit	8 23	92 77	50		Openshaw, 2000 Sirisomboon <i>et al.</i> , 2007
Coat	85 89	15 11	30		Openshaw, 2000 Sirisomboon <i>et al.</i> , 2007
Seed	3-7	93-97			Mattana Saturnino <i>et al.</i> , 2005 Jones & Miller, 1992
	5	95	70	37.4	Kandpal & Madan, 1995 Openshaw, 2000
			74	33.0-39.1	Ginwal <i>et al.</i> , 2004 Mattana Saturnino <i>et al.</i> , 2005
Shell			34.7-41.6 34.3-46.1		Ginwal <i>et al.</i> , 2004 Makkar <i>et al.</i> , 1997
	11 10 10	89 90 90	34.3		Vyas & Singh, 2007 Openshaw, 2000 Trabi, 1998
			37.6 29.9-31.9		Mattana Saturnino <i>et al.</i> , 2005 Martinez Herrera <i>et al.</i> , 2006
Kernel			58.4-65.3 53.9-65.7 65.7	46.2-58.1	Ginwal <i>et al.</i> , 2004 Makkar <i>et al.</i> , 1997 Openshaw, 2000
	3.0 3.1-5.8 2.2-11.3	97.0 94.2-96.9 88.7-97.8		46.0-48.6 48.5	Kandpal & Madan, 1995 Banerji <i>et al.</i> , 1985 Trabi, 1998
			68.1-70.1 62.4		Martinez Herrera <i>et al.</i> , 2006 Mattana Saturnino <i>et al.</i> , 2005
				21.0-74.0	Shah <i>et al.</i> , 2005

Jongschaap *et al.*, 2007. Claims and Facts on *Jatropha curcas* L. (Table 1, page 12).

Nutrient requirements

6000	DM fraction			kg	N%	kg	P%	kg	K%	kg	
Wood	0.25		0.25	1500	3.34	50	0.09	1	2.87	43	
Leaves	0.25		0.25	1500	4.70	71	0.34	5	3.00	45	
Fruit	0.50										
	Coat	0.30	0.15	900	0.75	7	0.05	0	4.23	38	
	Seed	0.70									
		Shell	0.35	0.12	735	0.50	4	0.03	0	1.50	11
		Kernel	0.65	0.23	1365	3.00	41	1.00	14	1.00	14
Sum			1.00	6000		172		21		151	

10000	DM fraction			kg	N%	kg	P%	kg	K%	kg	
Wood	0.25		0.25	2500	3.34	84	0.09	2	2.87	72	
Leaves	0.25		0.25	2500	4.70	118	0.34	9	3.00	75	
Fruit	0.50										
	Coat	0.30	0.15	1500	0.75	11	0.05	1	4.23	63	
	Seed	0.70									
		Shell	0.35	0.12	1225	0.50	6	0.03	0	1.50	18
		Kernel	0.65	0.23	2275	3.00	68	1.00	23	1.00	23
Sum			1.00	10000		287		35		251	

Recycling

- Re-use of (macro-) nutrients
 - 67% withdrawal from senescent leaves
 - 33% as organic input
 - Efficiency of decomposition (soil & climate dependent)

- Senescent materials
 - Leaves, prunings, fruit coats and preferably press cake, should remain in the field to secure sustainable production!

Implications of (not) recycling

	DM fraction			kg	N%	kg	P%	kg	K%	kg
Wood	0.25		1.00	1500	3.34	50	0.09	1	2.87	43
Leaves	0.25		1.00	1500	1.23	18	0.15	2	1.50	23
Fruit	0.50									
	Coat	0.30	0.90	810	0.75	6	0.05	0	4.23	34
	Seed	0.70								
	Shell	0.35	0.90	662	0.50	3	0.03	0	1.50	10
	Kernel	0.65	0.59	799	3.00	24	1.00	8	1.00	8
Sum				5270		102		12		118

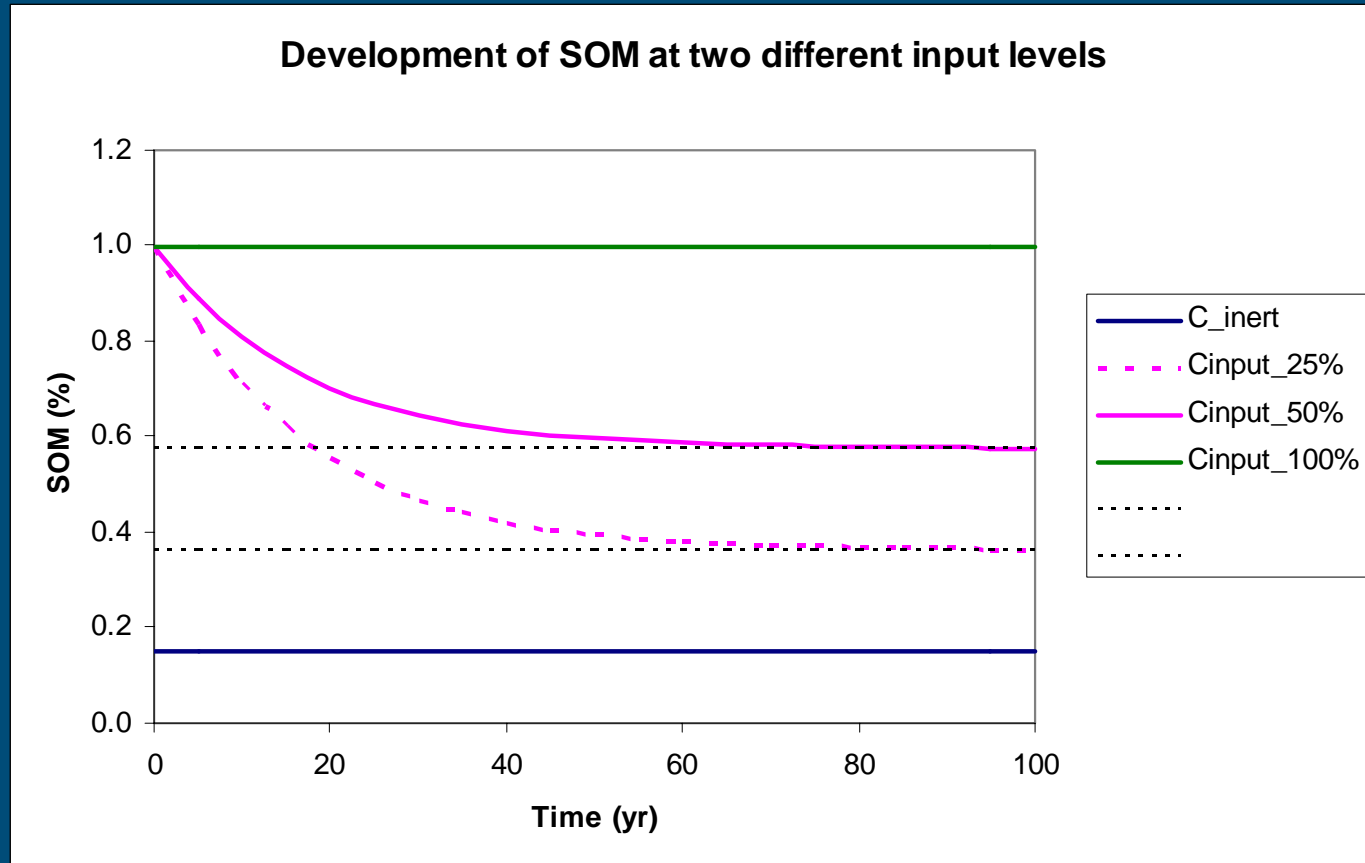
	DM fraction			kg	N%	kg	P%	kg	K%	kg
Wood	0.25		0.00	0	3.34	0	0.09	0	2.87	0
Leaves	0.25		1.00	1500	1.23	18	0.15	2	1.50	23
Fruit	0.50									
	Coat	0.30	0.00	0	0.75	0	0.05	0	4.23	0
	Seed	0.70								
	Shell	0.35	0.00	0	0.50	0	0.03	0	1.50	0
	Kernel	0.65	0.00	0	3.00	0	1.00	0	1.00	0
Sum				1500		18		2		23



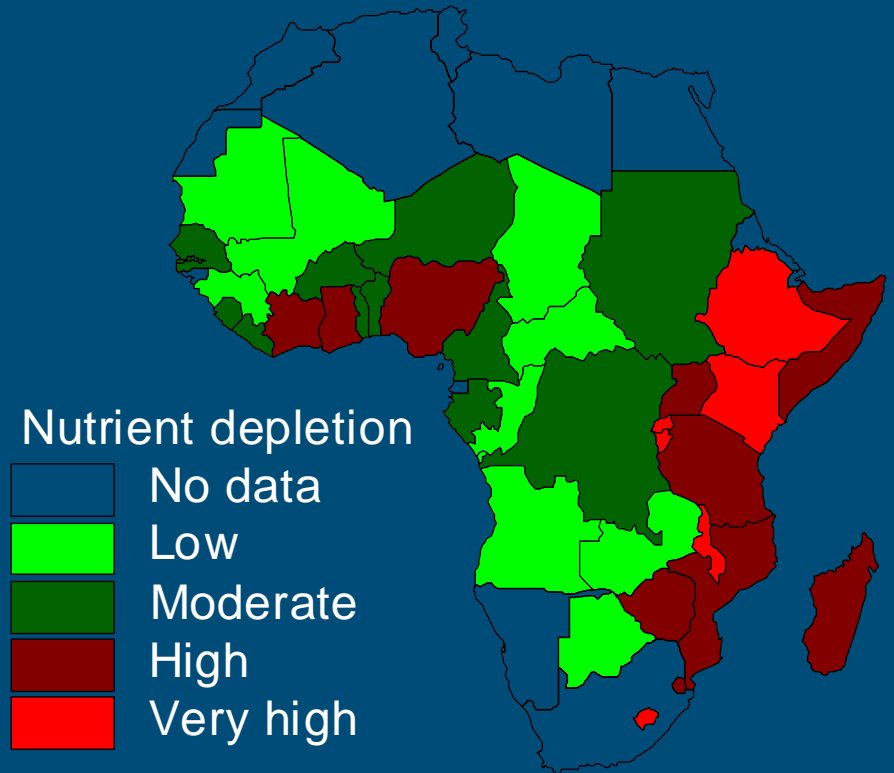
Soil Organic Matter

- Increase soil organic matter by senescent leaves, prunings, fruit coats and press-cake leads to
 - An increase of
 - Soil aggregation and soil stability
 - Water holding capacity
 - And prevents
 - Erosion
- Decomposition of OM releases nutrients and closes the nutrient cycle

Recycling nutrients



Increasing food against a deteriorating resource base



Decrease of the crop yield potentials increase

Conclusions

- For good performance, *Jatropha curcas* needs like any other crop, radiation, water, nutrients and... care!
- In short term notice agronomy measures may improve *Jatropha curcas* performance considerably, by improving resource use efficiencies
- Recycling of organic matter and nutrients is a must for a sustainable production

References

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End module 3

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