GLOBAL USE OF CACTUS AS LIVESTOCK FEED

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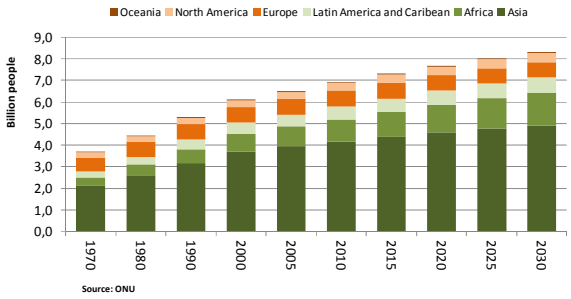
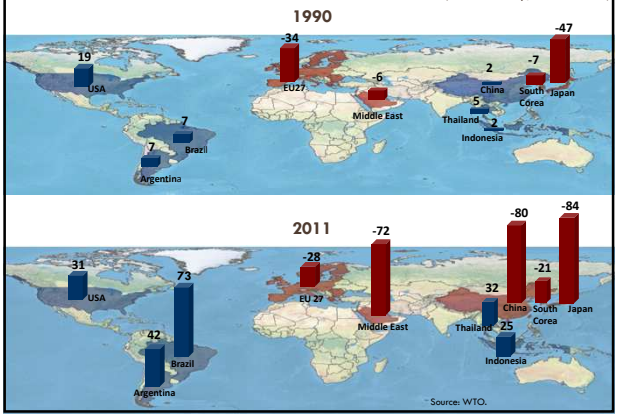
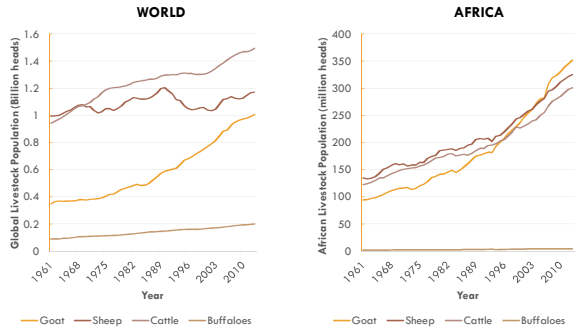
Global human population is increasing...



Agriculture trade balance on selected countries: largest deficits e surplus (billion US$, WTO data)



Livestock population is also increasing...



Drylands will play an increasing role in feeding the world

REGION	ARIDITY ZONE							
	Arid		Semi-arid		Dry subhumid		All drylands	
	(1 000 km²)	(%)	(1 000 km²)	(%)	(1 000 km²)	(%)	(1 000 km²)	(%)
Asia (incl. Russia)	6 164	13	7 649	16	4 588	9	18 401	39
Africa	5 052	17	5 073	17	2 808	9	12 933	43
Oceania	3 488	39	3 532	39	996	11	8 016	89
North America	379	2	3 436	16	2 081	10	5 896	28
South America	401	2	2 980	17	2 223	13	5 614	32
Central America and Caribbean	421	18	696	30	242	10	1 359	58
Europe	5	0	373	7	961	17	1 359	24
World total	15 910	12	23 739	18	13 909	10	53 558	40

> 2 billion people live on drylands

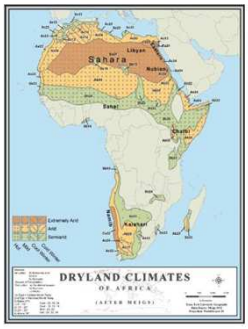
Source: UNSO/UNDP 199

Rangeland productivity in the world

Rangeland type	Location	Annual rainfall (mm)	Annual productivity (kg DM ha^{-1})	Carrying capacity (AU ha^{-1})	Source
Grassland	Bloemfontein	560	1,558	---	Snyman (2002)
Savana	Pongola region	568	2,100-3,500	0.24	Fynn and Connor (2000)
Shrubland	W Australia	228	625	---	Holm et al. (2003)
Mixed-grass rangeland	Wyoming	384	816-1,224	---	Schuman et al. (1999)
Praire	NW Oklahoma	576	1,490	0.17	Gillen and Sims (2004)
Eucalypt woodland	NE Queensland	535	2,800	1.63*	Ash et al. (1995)
Caatinga + Buffel	NE Brazil	605	1,940	0.16	Ydoyaga Santana et al. (2011)

*initial live weight of 170 kg

Drylands in Africa



Land use in Drylands

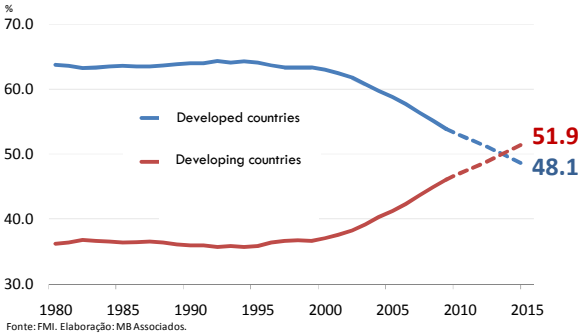
- ✓ 61% of drylands are used as grasslands
- ✓ 61% of drylands represent 32,670,380 km^2
- ✓ If only1% of this land were planted with cactus, we would have 32.7 million ha with this crop
- ✓ However...
- ✓ Our estimates indicate only ~2 million ha of cultivated cactus + 3 million ha of native cactus

Our focus today: cactus as a forage

Annual crops + semiarid = RISK

- Erratic rainfall distribution in the semiarid
- Shallow soils with low water storage capacity
- Drought often occurs
- Grain productivity in these areas is low
- In the semiarid of Brazil, maize grain productivity is 600 - 800 kg per ha/year

Share of world GDP between developed and under developed countries in Purchasing Power Parity (%)

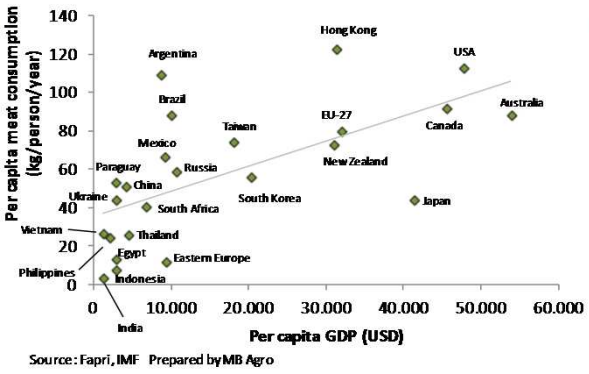


Demand for grain to produce livestock products will grow as prosperity increases

	1993	2020
	Million metric Tonnes	
China	73	183
Asia (developing count.)	32	70
Total Developing count.	194	418
World	636	945

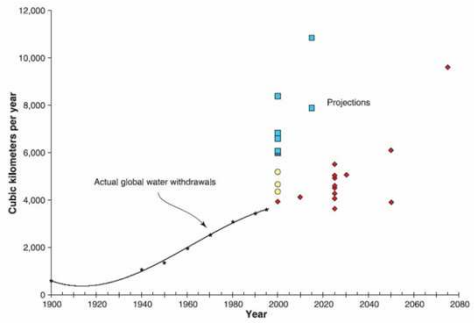
Rosegrant and Ringler (1999)

Per capita meat consumption x GDP - 2009



Source: Fapri, IMF Prepared by MB Agro

Projections of water use and actual global water withdraws
SCIENCE VOL 302 28 NOVEMBER 2003



In summary

- The world demand for grains is increasing
- Water is a valuable resource, including for livestock
- Drylands may contribute more for food production
- **In this scenario…….**

Cactus is a viable option

Cactus productivity in the semiarid of Brazil may go up to 20 Mg DM per ha/year (and 180 Mg of water) in rainfed systems

Cactus replacing maize

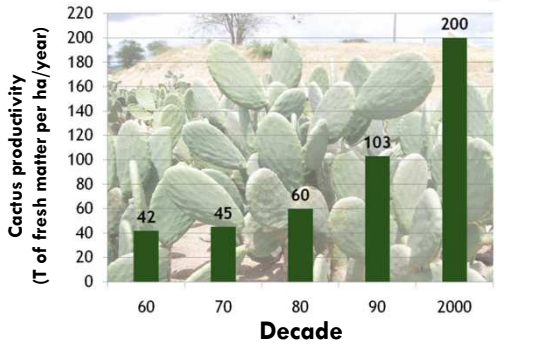
Cactus represents 75% of maize grain energy, but produces at least 20 x more in harsh semiarid environments

I said 20x more!

That is a lot!!

Cactus Production Systems

Increment of cactus productivity in experimental areas of NE Brazil in the last 50 years



Cactus production systems

Cactus used to land restoration and rehabilitation in North Africa

Cactus planted in terraces to reduce soil erosion and to provide forage

Cactus planted to reduce soil and wind erosion and to recover vegetation

Cactus and soil conservation

Crop	Soil losses (t ha^{-1})
Cotton	11.00
Maize	4.00
Cactus	2.00
Guinea grass *(Panicum maximum* Jacq.)	0.02

Fonte: Margolis et al. (1985)

Extensive systems

Cactus production systems

Cactus intercropped with cash crops in NE Brazil

Cactus intercropped with sorghum in NE Brazil

Cactus intercropped with maize and phaseolus (bean) in NE Brazil

Cactus production systems

Cactus intercropped with legume trees in NE Brazil

Legumes may add N to the system, providing fiber and CP to mix with cactus energy in ruminant diet

Cropping system	Cactus Biomass	Legume Biomass	Total Biomass
	Mg DM ha^{-1} yr^{-1}		
Cactus + Gliricidia	13.6 a	4.2 a	17.8 a
Cactus + Leucena	14.0 a	2.6 b	16.6 a
Cactus	16.9 a	-	16.9 a
Standard error	1.0	0.2	0.8

*Means followed by small case letters in the collumn do not differ by Tukey test at 5%.

Cactus production systems

Cactus intensively managed: fertilized, planted in higher population density, and in some cases, irrigated



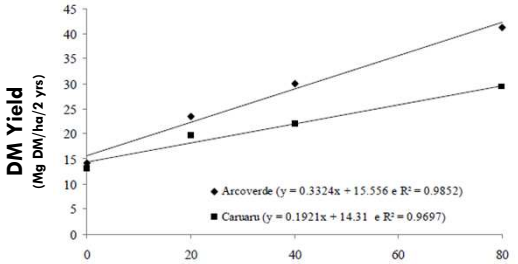

With just a bit of water…

- Spacing 2 m x 0.1 m
- 5 L m^{-1} week^{-1} (or 2.5 mm/wk)
- In situ water catchment
- Drip irrigation (C3S1 water)
- 23 T DM ha^{-1} Yr^{-1}
- 0.1 ha is enough to sustain two cows during 180 d with 50% of cactus in the diet

Lima et al., 2013

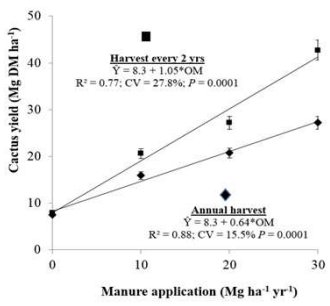

Cactus Agronomic Potential

What is the limit?



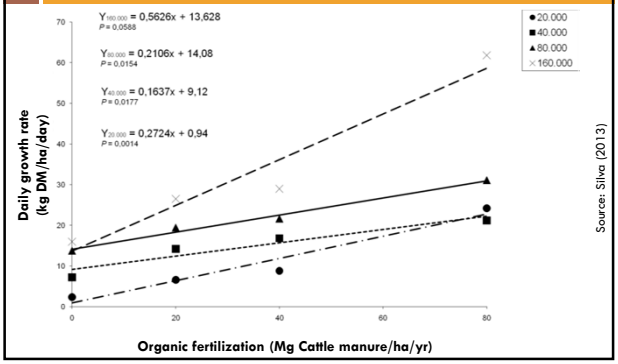
Santos et al, 2009

What is the limit?



Souza, 2015

Agronomic practices and plant population affect cactus productivity



Source: Silva (2013)

Cactus Agronomic Potential

✓Potential productivity of **20 Mg of DM/ha/yr**

✓Carrying capacity of **4.8 AU/ha/yr**

✓This is **57.6 x** higher than the carrying capacity of native rangeland (12 ha/AU/yr)

✓In low-input systems, 5 – 6 Mg of DM/ha/yr is easily obtained

Intensifying a small area with Cactus improve sustainability of small farms

Production System	Gross Income
Native Rangeland (NR)[1]	x
Improved Rangelands[2]	4 x
50% NR + 50% Buffel grass (BG)[3]	4 x
50% NR + 40% BG + **10% Cactus**[4]	12.8 x

Source: Dubeux Jr. 2011

Cactus nutritive value and processing

Cactus forage chemical composition varies with:

- Cultivar
- Development stage
- Fertilization
- Plant population
- Cladode order

OPUNTIA - AVERAGE CHEMICAL COMPOSITION

Item	(%)
Dry Matter	8 – 12
Crude Protein[1]	4 – 7
NDF[1]	25 – 30
ADF[1]	18 – 20
TDN[1]	65 - 70
NFC[1]	50 - 55

1- DM basis

Simple rules

- Cactus cannot be fed alone.
- Supplement with CP and fiber in a mixed diet.
- Cactus is rich in soluble carbohydrates, thus, avoid adding molasses and limit the amount of grain in the diet.

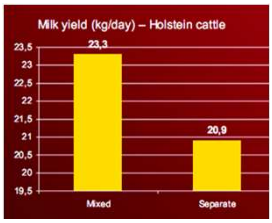
Harvesting, processing, and feeding

Cows select cactus

Different products available in the market

Feeding system with tractor

Mixing ingredients vs. separate ingredients (Pessoa et al., 2004 – Brazil)



Diet: 39 % cactus + 31 % sorghum silage + 30 % concentrate

Wasted fruits in feed blocks

Lambs (Chermiti & Ferchichi, 2000)

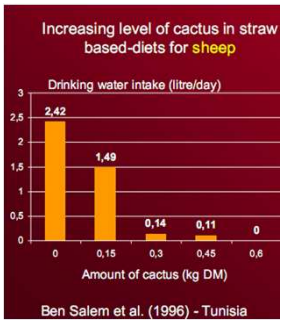
Diets	Daily gain, g
Hay + barley grain	154
Hay + feed blocks (cactus fruit)	163

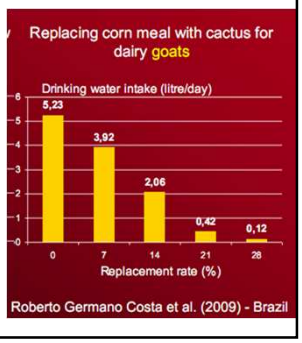
Other processing forms

- ✓ Cactus ensiled with other forages might be an option during pruning (Abidi et al., 2013)
- ✓ Sundried cactus replaces coarsely ground cactus and increases marketability as a feed (de Waal et al., 2013)
- ✓ Fermented cactus increases true protein (Oliveira, 2001; Araújo et al. 2005)

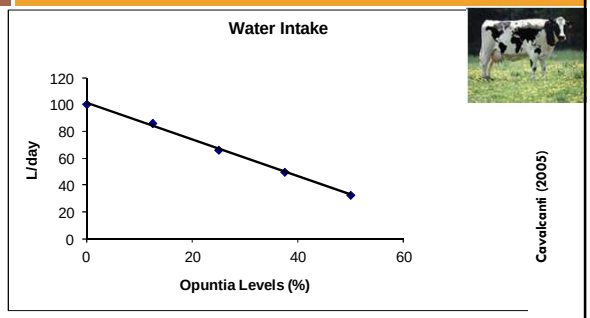
Water intake

Cactus helps solving watering problems in arid areas



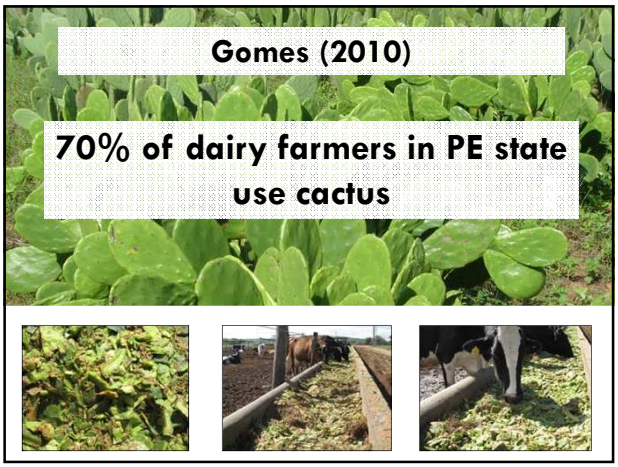


Water intake by dairy cows



Opuntia in replacement of Tifton hay – Dairy cows

Animal performance



Performance of dairy cows fed cactus with or without maize grain

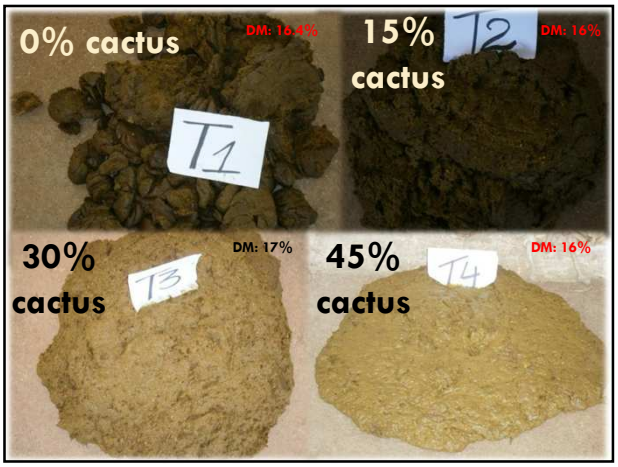
ITEM	Treatments	
	With Maize	Without Maize
Dry matter intake (kg DM/day)	15.5 a	15.4 a
TDN intake (kg/day)	9.4 a	9.1 a
Fat corrected Milk yield (kg/day)	15.9 a	15.4 a
% of Cactus	**36.0**	**50.0**
% of concentrate feeding	**27.0**	**13.0**
kg of milk: kg of concentrate	**3.5**	**7.0**

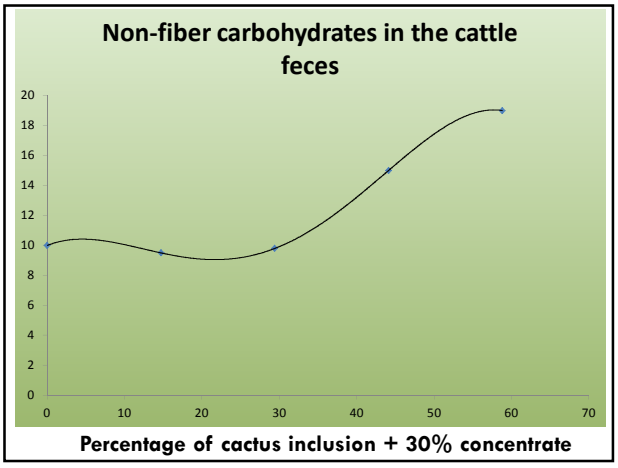
Araújo et al. (2004)

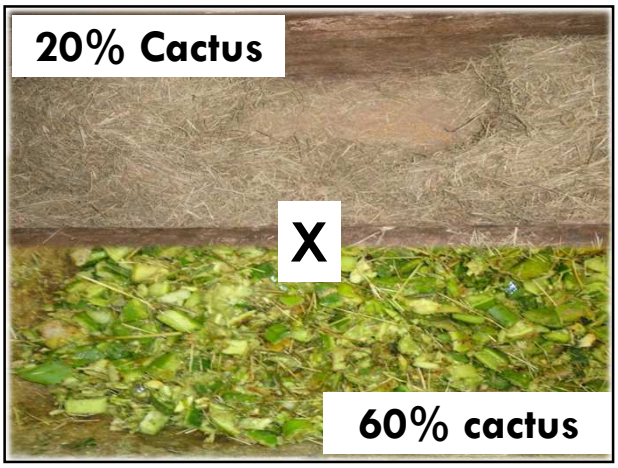
Dietary limits for NDF, ADF, and NFC (NRC, 2001)

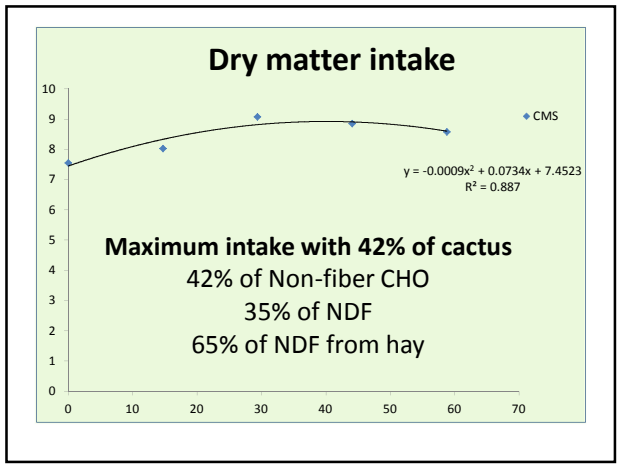
TAKE HOME MESSAGE:

50-65% of the fiber source should come from non-cactus roughage and NFC should be < 42%









Cactus replacing concentrate feeding

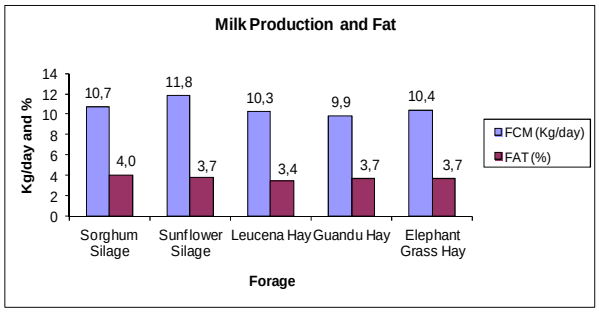
Many farmers rely on expensive concentrate feeding

Solution?

Cactus + urea + Fiber

Cactus + legume

Opuntia (60% plus 200g of urea) associated with different forages - Dairy Cows



Wanderley et al. (2006)

Urea replacing soybean meal for Lactating Dairy cows

Variable	% Urea				Effect
	0	0.8	1.6	2.4	
DMI (kg/day)	19.4	18.8	19.0	17.2	Linear
FCM (kg/day)	18.8	18.6	18.1	17.5	Linear
Fat (%)	3.4	3.4	3.6	3.4	NS
Urea (g/day)	0	150	300	420	--
Cactus %	**31.9**	**34.9**	**37.8**	**40.9**	**--**
Soybean meal %	**21.9**	**18.0**	**14.0**	**10.4**	**--**

Melo et al.(2003)

Legume replacing soybean meal for Lactating Dairy cows

Cactus + *Clitoria ternatea*

Reduced use of soybean meal in 67%

	Cactus + Legume Hay + 0.8 kg Soybean meal	Cactus + Bagasse + 2.4 kg Soybean meal	CV (%)
Milk production (kg/cow/day)	12.7 A	11.5 B	7.4

Dubeux et al., 2009

Cactus in dairy cattle diets

Item	Cactus in DM (%)			
	None	Low	Medium	High
Cactus	0	20	40	60
Forage	70	55	40	25
Concentrate	30	25	20	15
NDF	55	45	40	35
NFC	30	32	34	36
Cost	U$	U$	U$	U$

Cactus for dairy goats

	Cactus in the diet (%DM)				
	0	7	14	21	28
Milk yield (kg/day)	1.5	1.6	1.6	1.6	1.5
Milk fat (%)	3.8	3.8	3.7	3.5	3.0
DM intake (kg/day)	1.9	2.1	2.3	2.3	2.3
	Water intake (kg/day)				
Voluntary	5.2	3.9	2.1	0.4	0.1
Via cactus	0.00	1.7	4.3	7.1	9.1

*50% of Tifton hay in the diet

Costa et al, 2009

Concluding remarks

Concluding remarks

- Cactus is an important forage option to drylands.
- It is more adapted to these regions than annual crops; its nutritive value is close to maize grain.
- It is rich in energy and has low fiber and CP concentrations. If fed with urea cactus replace soybean meal.
- Limit in the diet is based on NFC.

Concluding remarks

- Cactus is an excellent source of water for the animals.
- Forage production may be part of a multipurpose production system of cactus.
- Fiting the right plant and the right animal to the semiarid environment makes more sense than changing the enviroment...