USE OF CACTUS FOR LIVESTOCK FEEDING

José C. Dubeux; UFRPE – Brazil

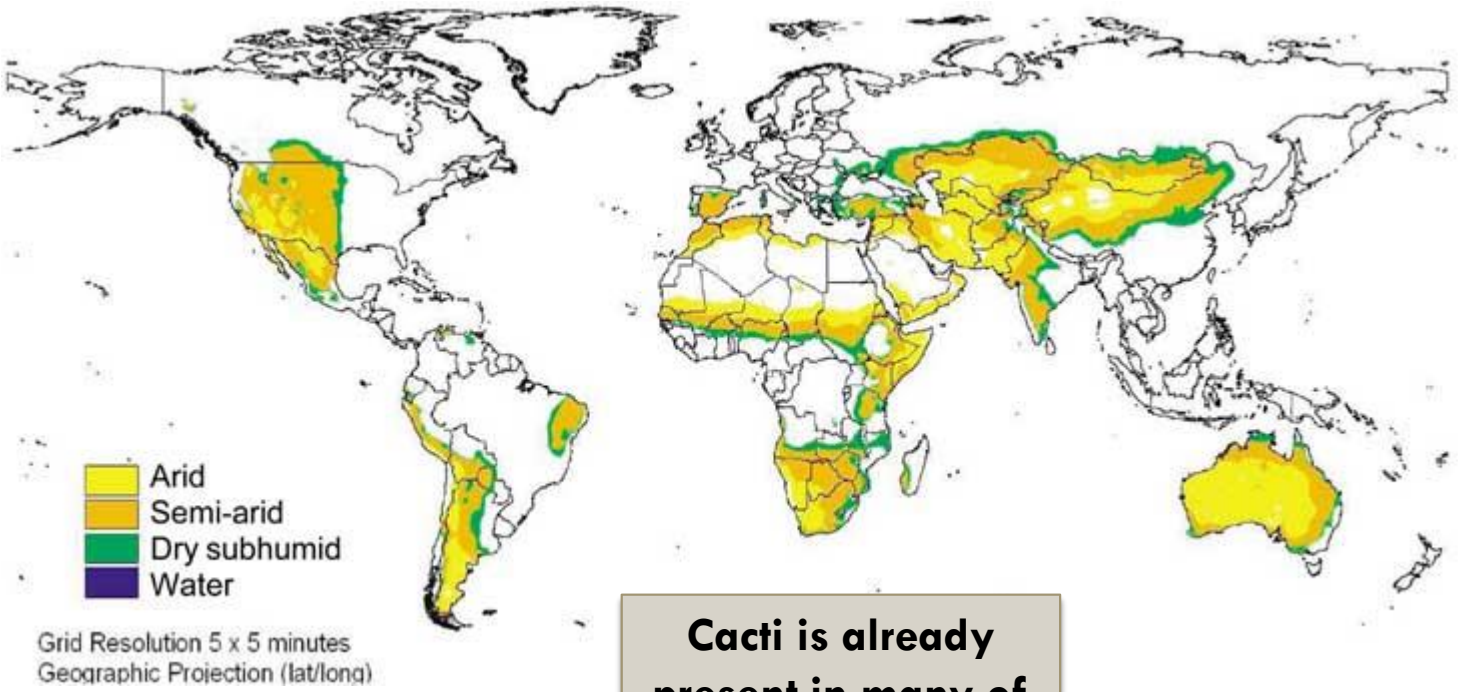
dubeux@dz.ufrpe.br

Outline

- Introduction
- Cactus Agronomic Potential
- Cactus Chemical Composition and Digestibility
- Processing and Feeding Systems
- Water Intake
- Animal Performance
- Concluding Remarks

Introduction

Arid and semiarid regions of the world



Cacti is already present in many of these dry areas

Source: **World** Soil Resources **Map, FAO**/EC/ISRIC

Few statistics ….

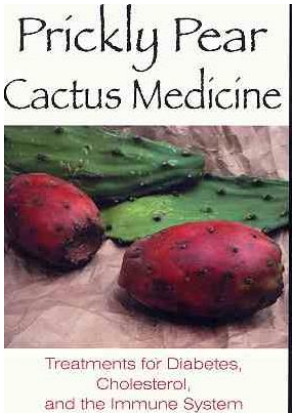
Regions/countries	Cultivated area (x 1000 ha)
Brazil	600
Other South American Countries	75
Mexico	230 + 3 M
Other North American countries	16
Tunisia	600
Algeria	150
Morocco	150
Italy	70
Total	1891 + ~ 3 M

Our focus today: dry areas

Dry areas

Wet areas

Cactus: a multi-purpose crop

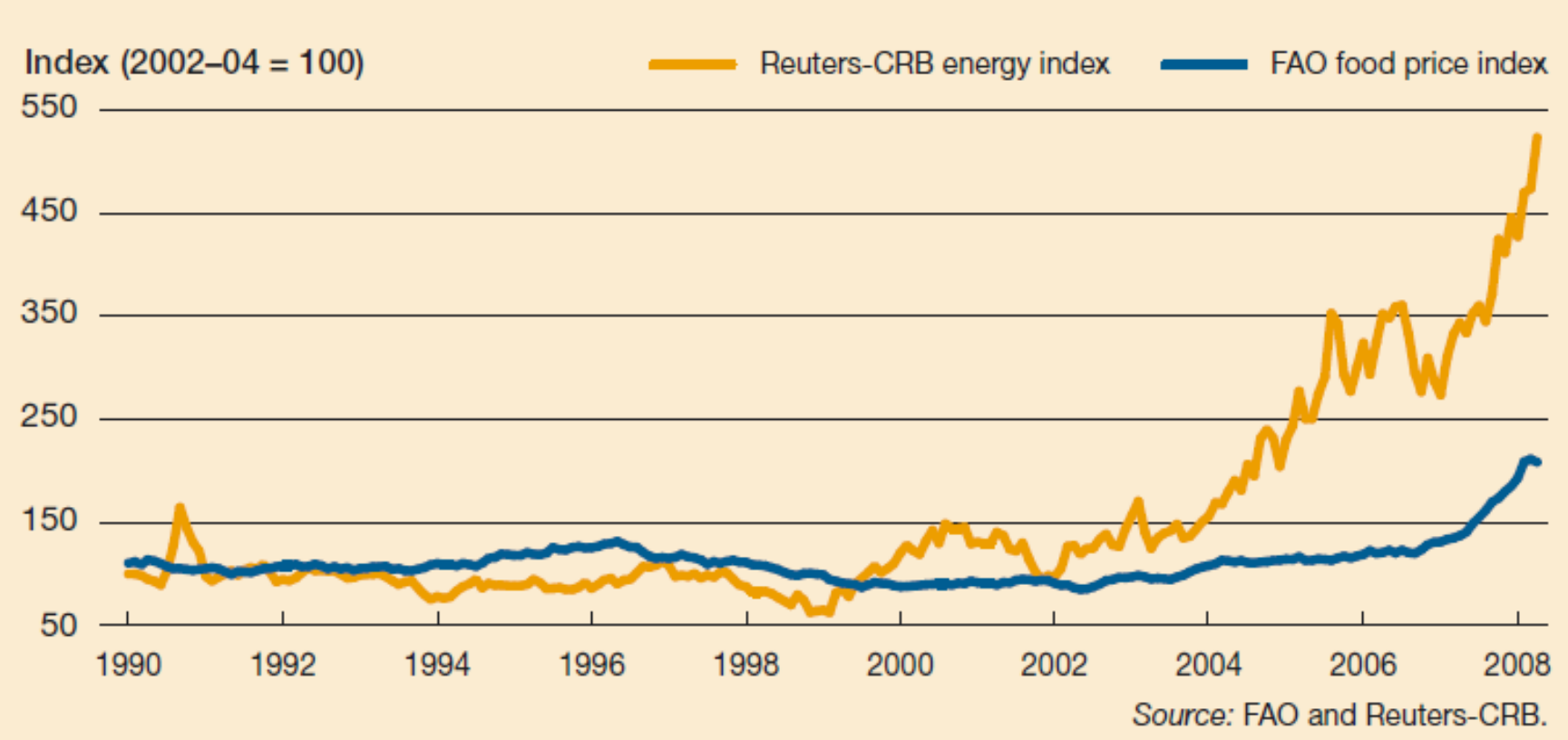


Our focus today: cactus as a forage

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

Grain price is increasing and is coupled to energy price



Major reasons: biofuels, transportation cost, fertilizers

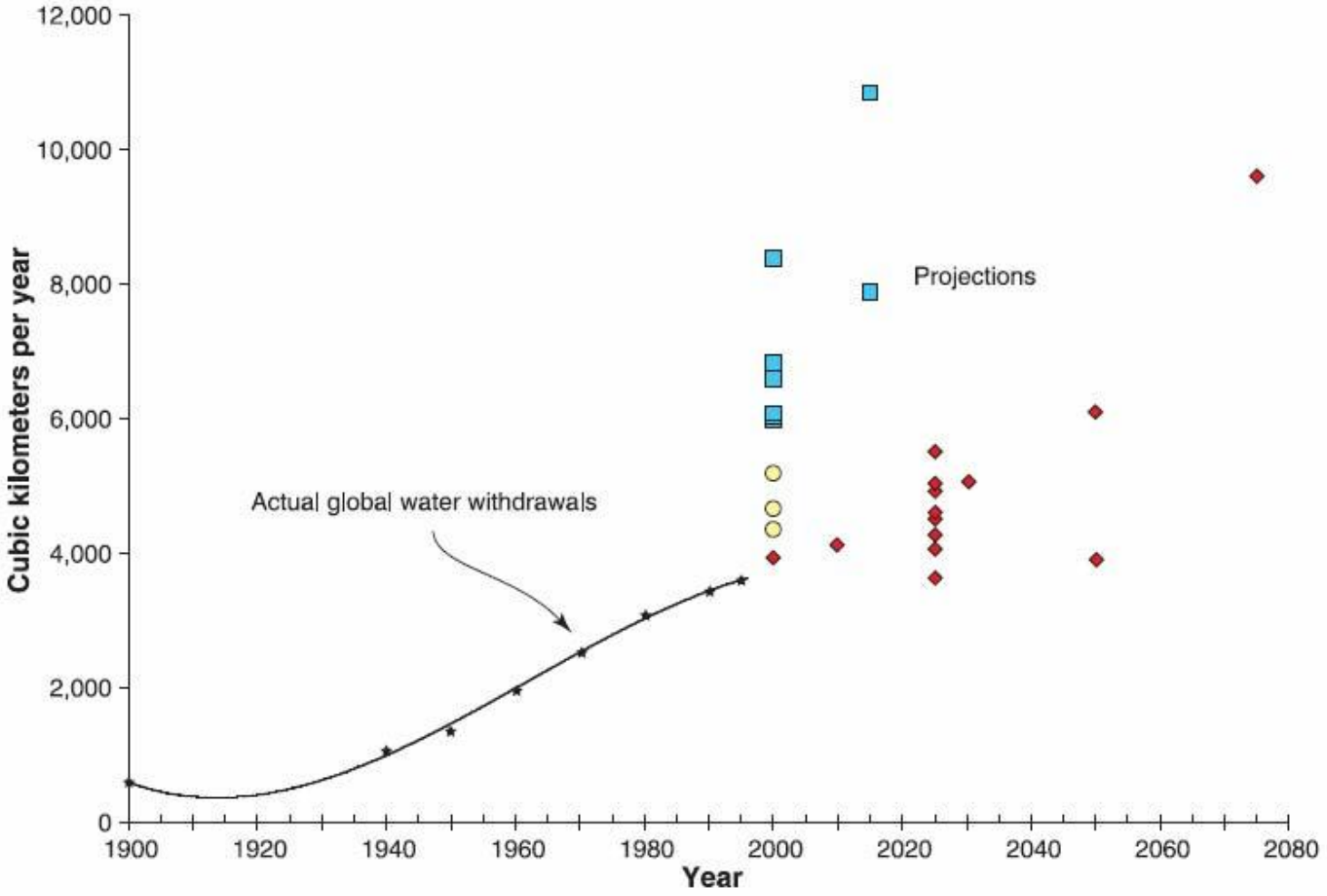
Demand for grain to produce livestock products will grow as prosperity increases

	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)

Projections of water use and actual global water withdrawals

SCIENCE VOL 302 28 NOVEMBER 2003



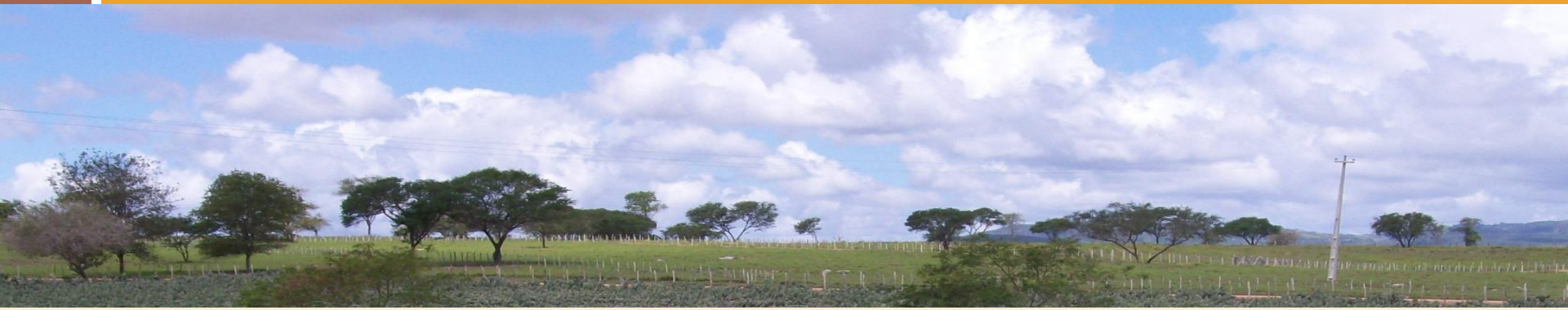
Cactus is a viable option

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

Cactus replacing maize

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

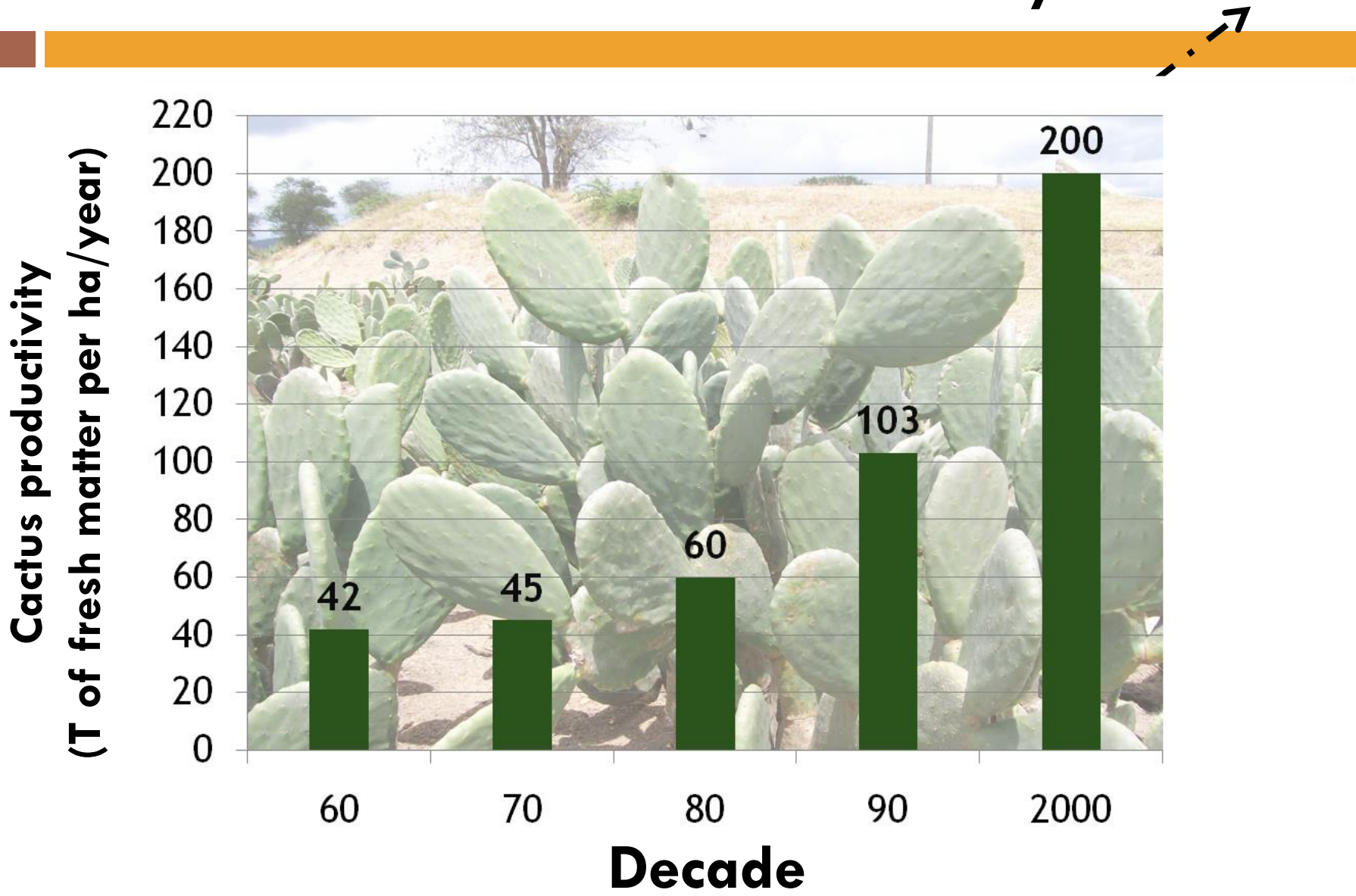
Objective



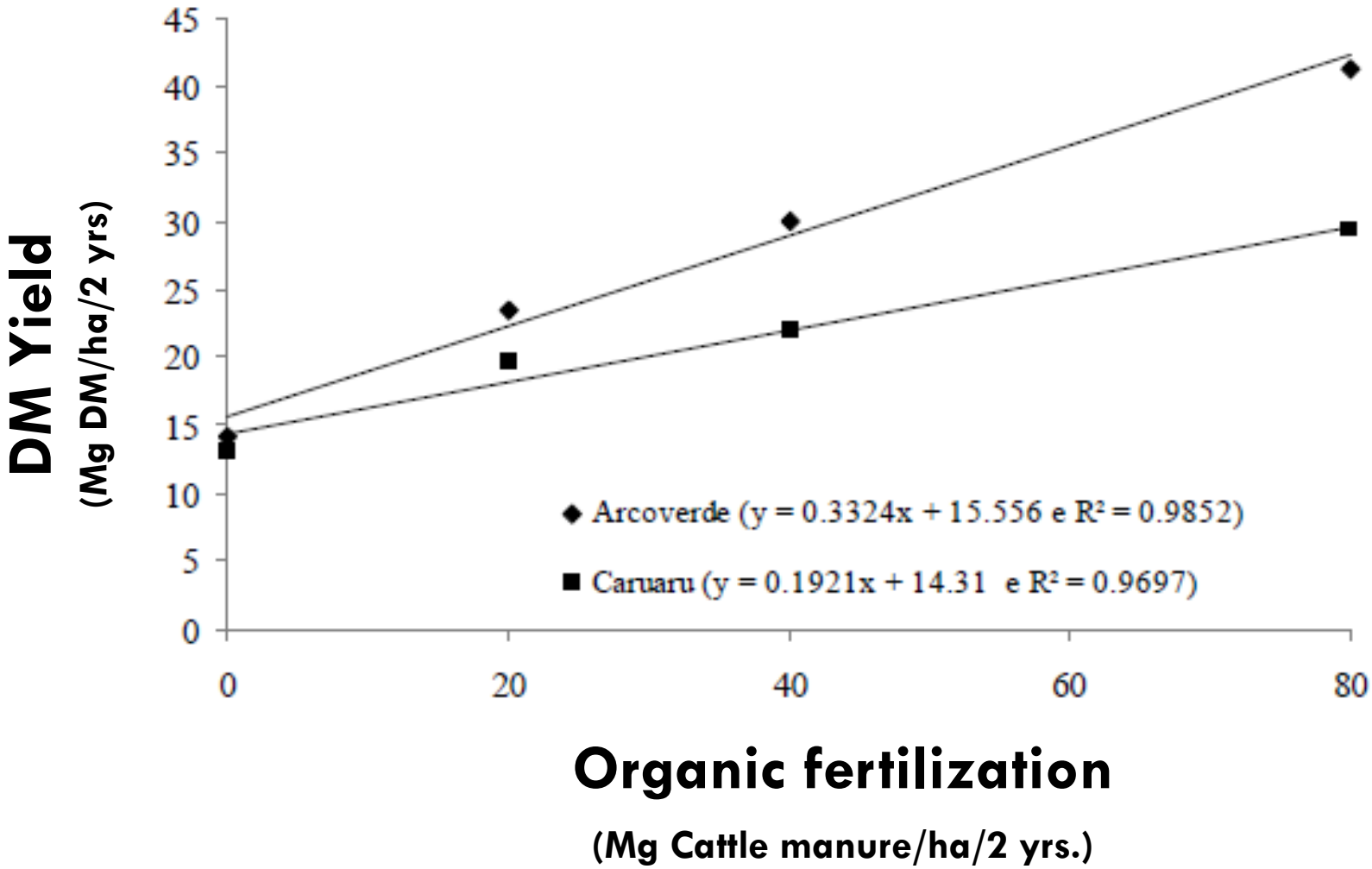
Describe the importance of use of cactus as a forage for livestocks in semiarid regions.

Cactus Agronomic Potential

Increment of cactus productivity in experimental areas of NE Brazil in the last 40 years

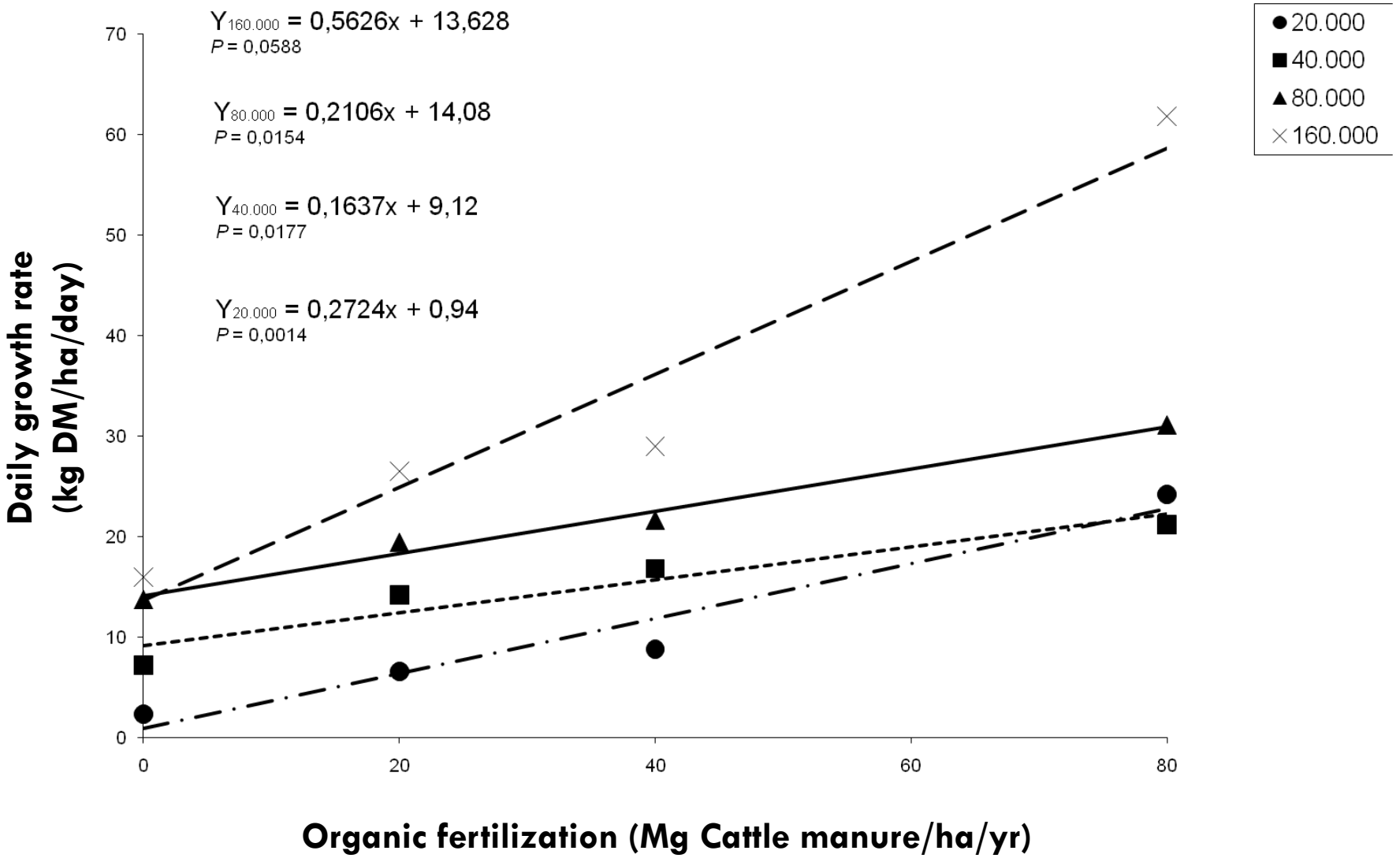


What is the limit?



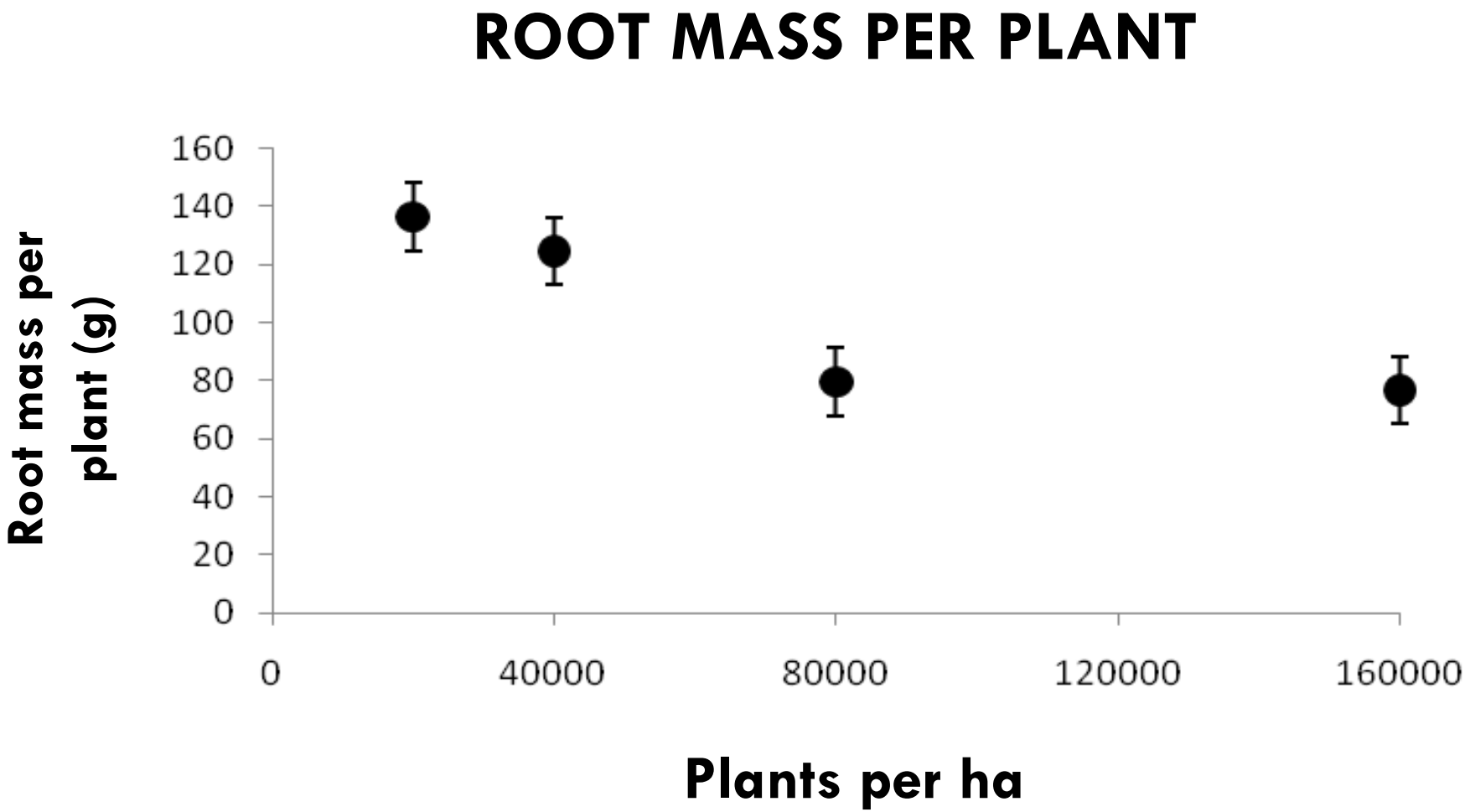
Santos et al, 2009

Agronomic practices and plant population affect cactus productivity



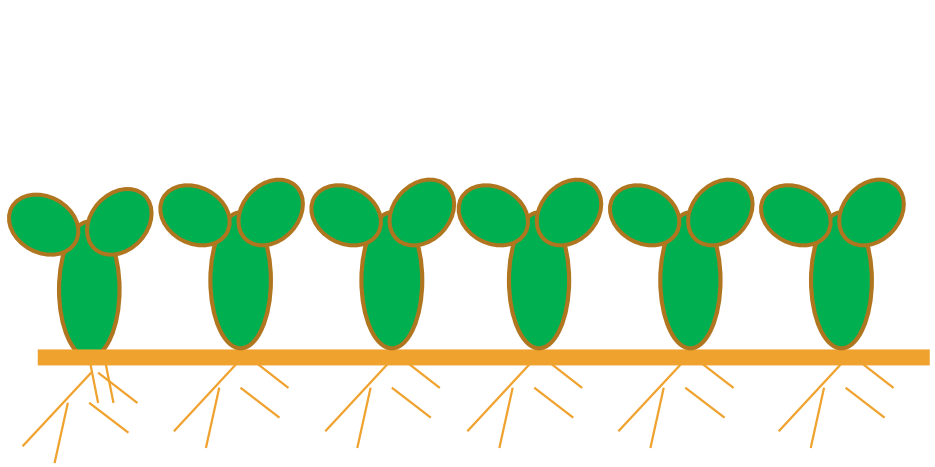
Source: Silva, N.G.M. – personal communication).

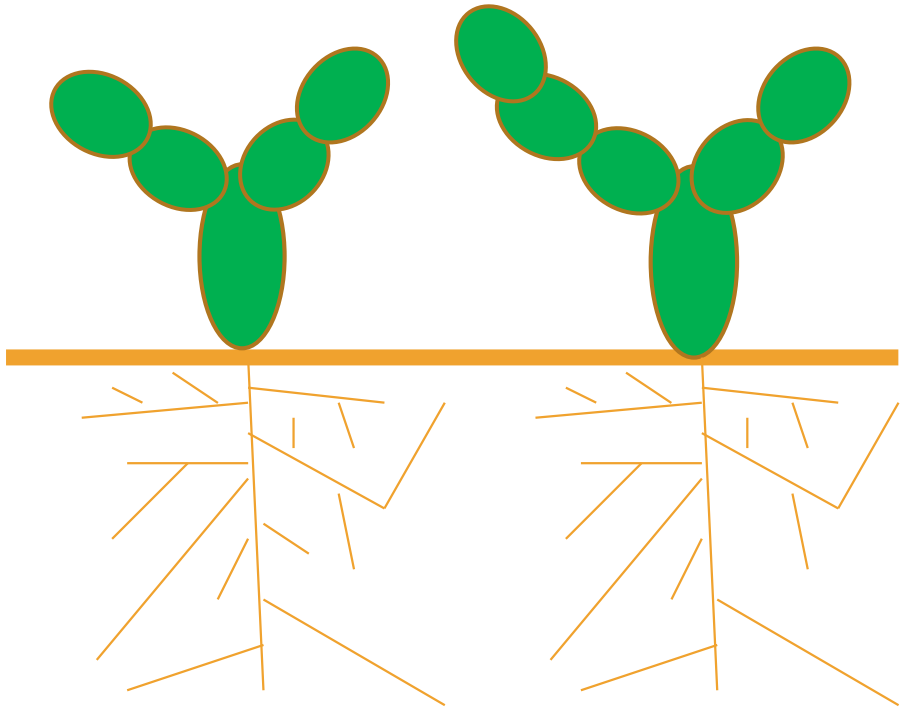
Root mass per plant decreases at dense populations (> 40,000 plants/ha)



Source: Dubeux Jr. et al. (2010)

More arid regions should work with less dense plant population





More dense plant population

Less dense plant population

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 chemical composition and digestibility

Cactus forage chemical composition varies with:

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

OPUNTIA - AVERAGE CHEMICAL COMPOSITION

Item	(%)
Dry Matter	11.3
Crude Protein[1]	5.6
NDF[1]	28.5
ADF[1]	20.1
TDN[1]	65.0
NFC[1]	55.4

1- DM basis

Cactus macronutrients

Species	N	P	K	Ca	Mg	S
	g kg $^{-1}$					
O. ficus-Indica[1]	6.7 – 20.6	1.1 – 4.7	25.8 – 33.4	14.9 – 34.4	5.9 – 7.4	1.7 – 6.1
O. engelmannii[2]	5.9 – 21.1	0.2 – 2.0	12.4 – 36.9	38.1 - 156	6.4 -18.4	---
N. cochenillifera[3]	6.7 – 10.5	1.0 – 1.6	8.3 – 12.1	---	---	0.9 – 1.9

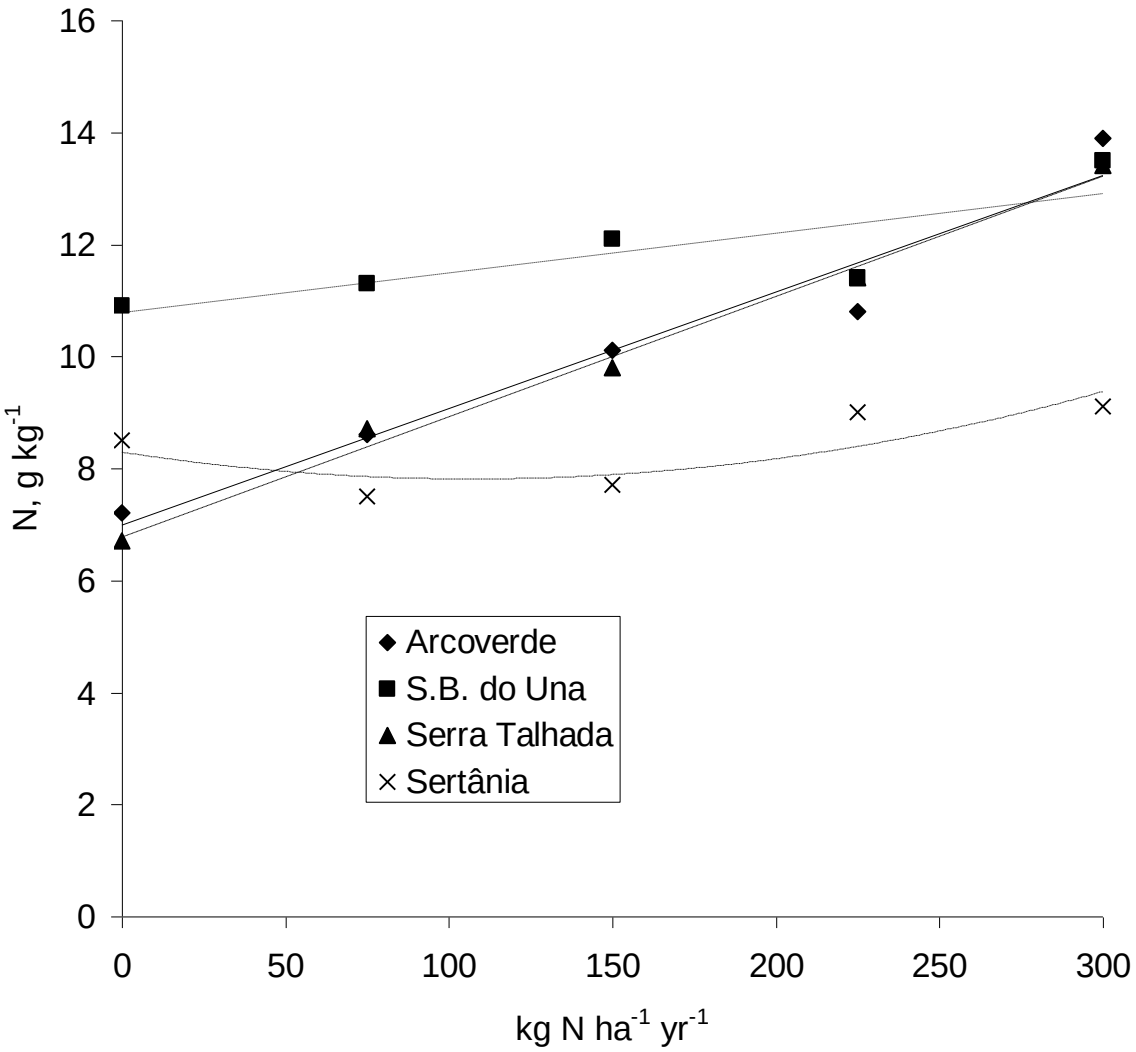
[1]OFI: Teles et al. (2004); Santos (1990); Santos et al. (1996); Dubeux Jr. et al. (2010)
[2]OE: Nobel et al. (1987); Nobel et al. (1987)
[3]NC: Dubeux Júnior e Santos (2005)

Cactus micronutrients

Species	Fe	Zn	Mn	Cu	B	Na
	mg kg $^{-1}$					
O. ficus-Indica[1]	89 - 128	62 – 109	182 – 687	6.5 – 7.1	1 – 23	---
O. engelmannii[2]	38 - 73	6 – 31	18 – 92	3.3 – 4.6	---	42 – 179
N. cochenillifera[3]	59 – 77	70 – 83	430 - 499	4	---	135 - 143

[1]OFI: Teles et al. (2004); Dubeux Jr. et al. (2010)
[2]OE: Nobel et al. (1987)
[3]NC: Dubeux Júnior e Santos (2005)

N fertilization increases cactus CP in *Opuntia ficus-indica* Mill.



Arcoverde
$y = 0.02x + 7$
$R^2 = 0.95$; $P < 0.001$

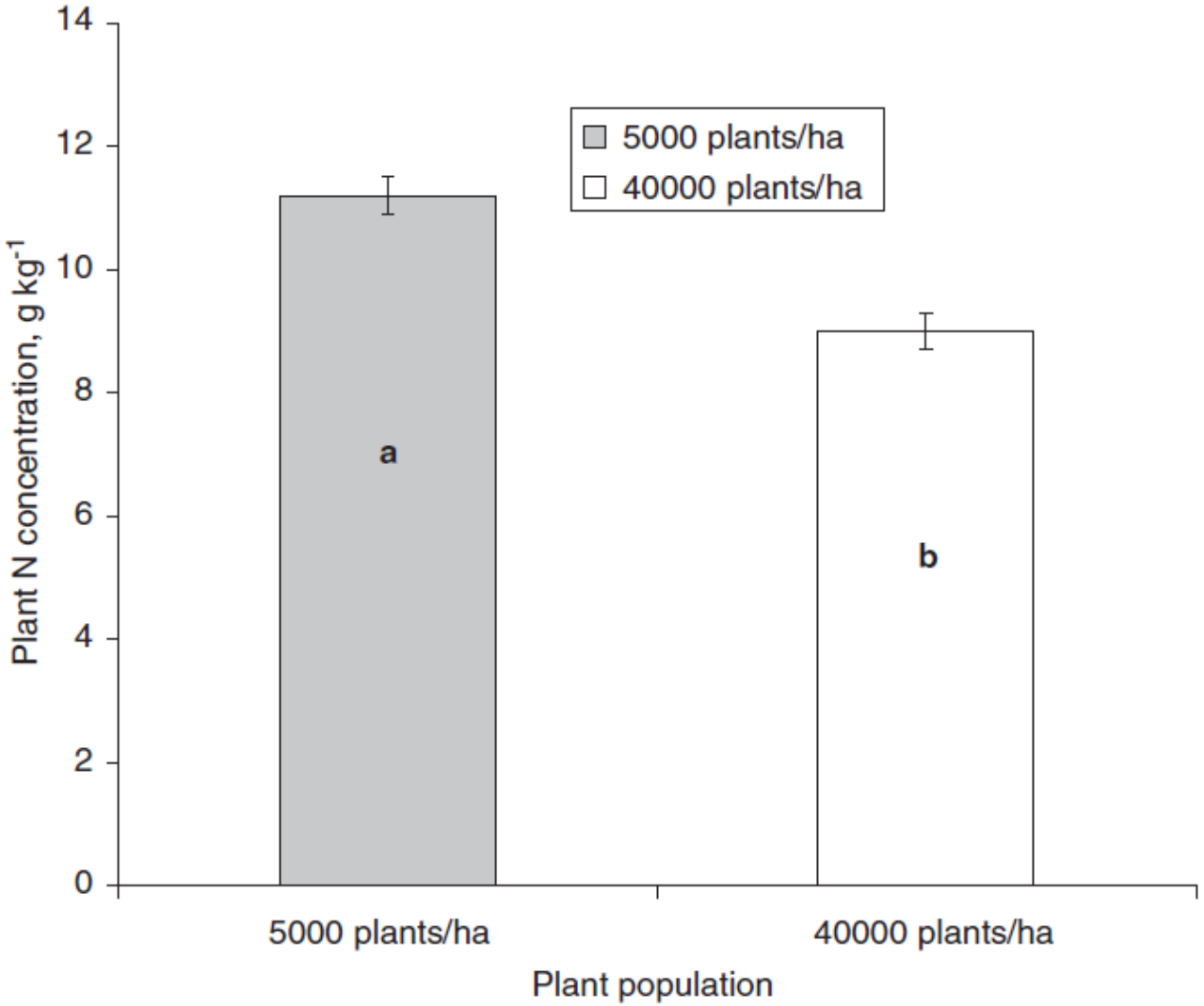
S. B. do Una
$y = 0.007x + 10.8$
$R^2 = 0.67$; $P < 0.03$

Serra Talhada
$y = 0.02x + 6.8$
$R^2 = 0.99$; $P < 0.001$

Sertânia
$y = 4E\text{-}05x^2 - 0.009x + 8.3$
$R^2 = 0.70$; $P < 0.05$

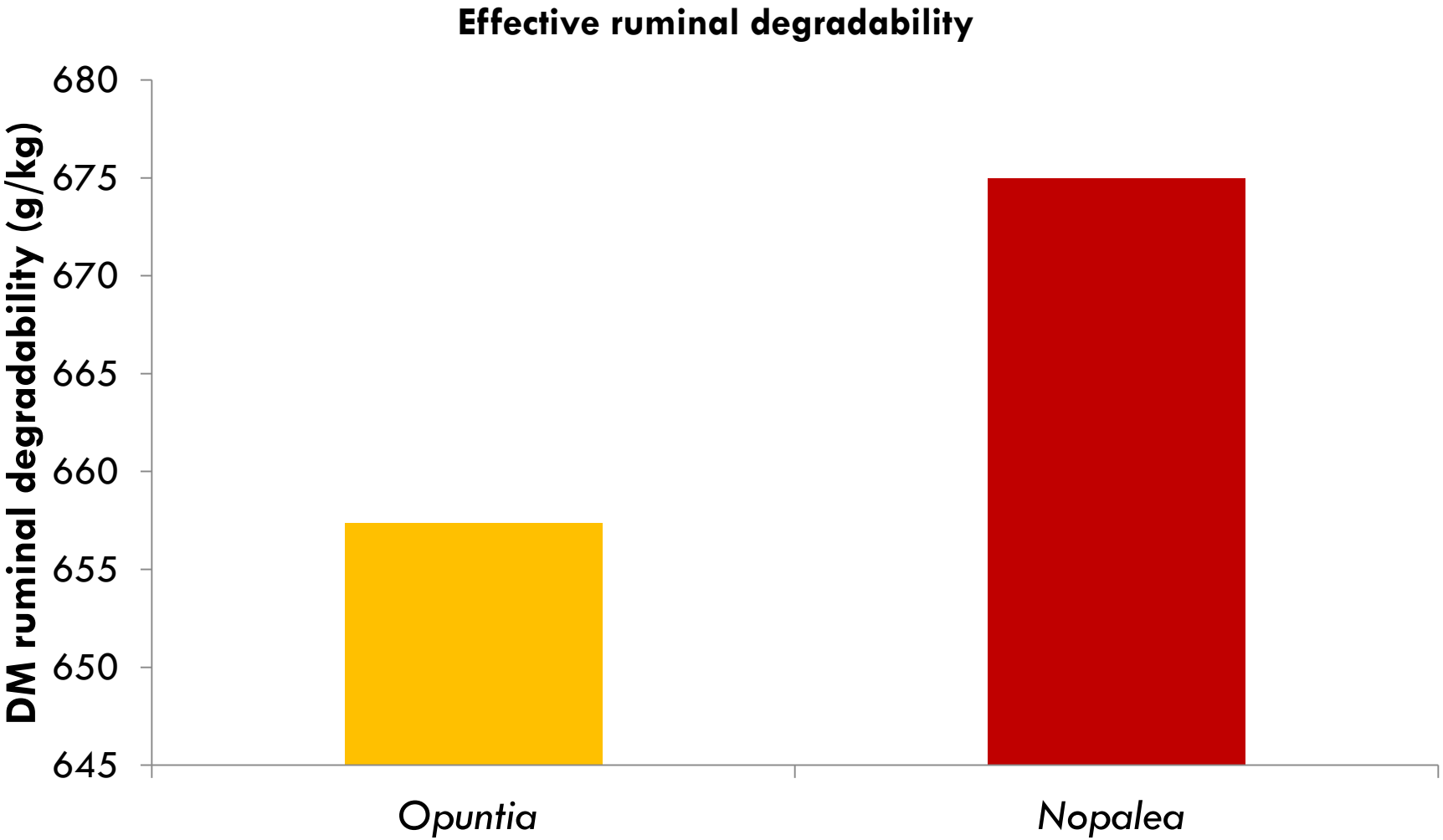
Fonte: Dubeux Jr. et al. (2006)

Plant population affects cactus (*Opuntia ficus-indica* Mill.) N concentration



Fonte: Dubeux Jr. et al. (2006)

Cactus ruminal degradability



Source: Batista et al., 2009; Batista et al., 2003

Cactus may be stored without changing its chemical composition and feeding value

Itens	Days of storage		
	0	8	16
DM (%)	10.3	8.2	9.8
CP (%)	5.3	5.1	5.2
DMI (% PV)	2.7	2.7	2.7
Milk Yield (kg/day)	11.3	11.1	11.2

Santos et al. (1998)

Simple rules

- Cactus cannot be fed alone (diarrhea, weight loss).
- 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.

Processing and Feeding Systems

Cactus Processing

- Cactus processing is important to:
  - Reduce cladode size
  - Prepare total mixed ration
  - Avoid selection by animals and increase intake
  - Mix cactus well with urea or concentrate feeding

Cactus chopped by knife

Click on the image to open video

Cactus chopped by machine

Click on the image to open video

Cactus chopped by machine

Click on the image to open video

FEEDING SYSTEM WITH TRACTOR

Click on the image to open video

Processed cactus increases DM intake

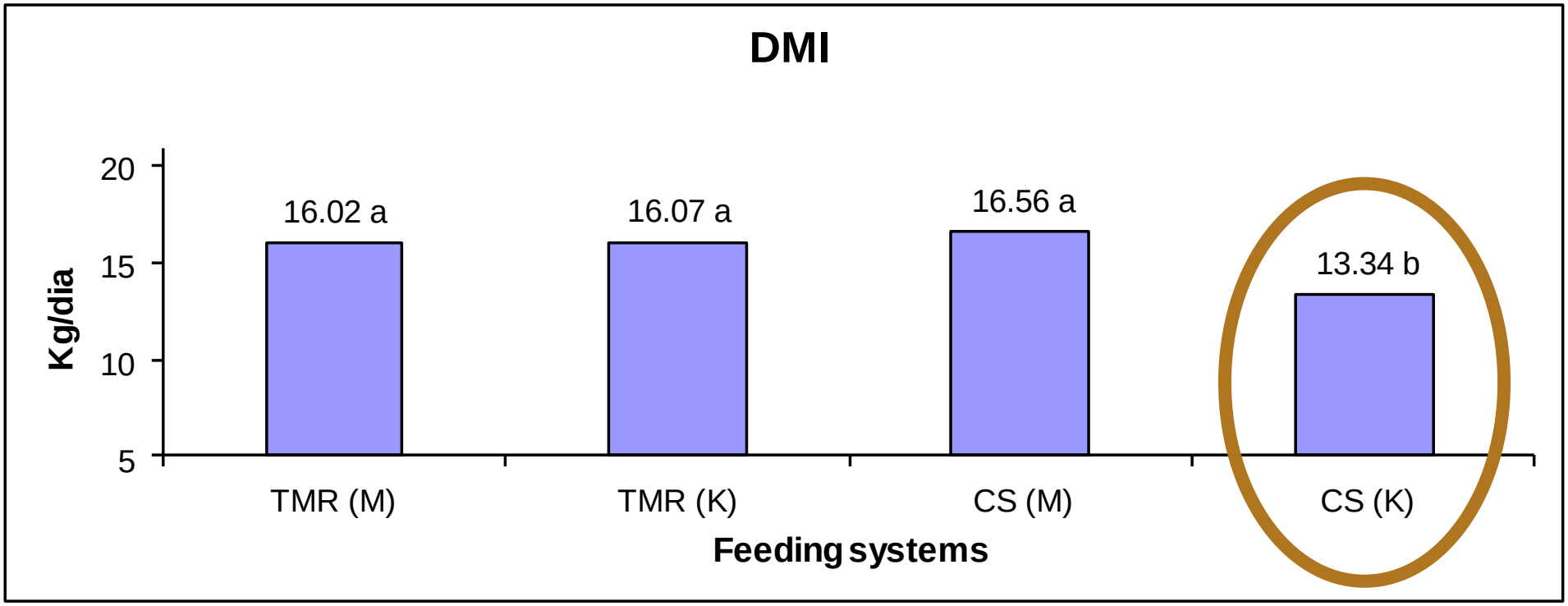
Click on the image to open video

Processing mixes diet ingredients

Click on the image to open video

Different products available in the market

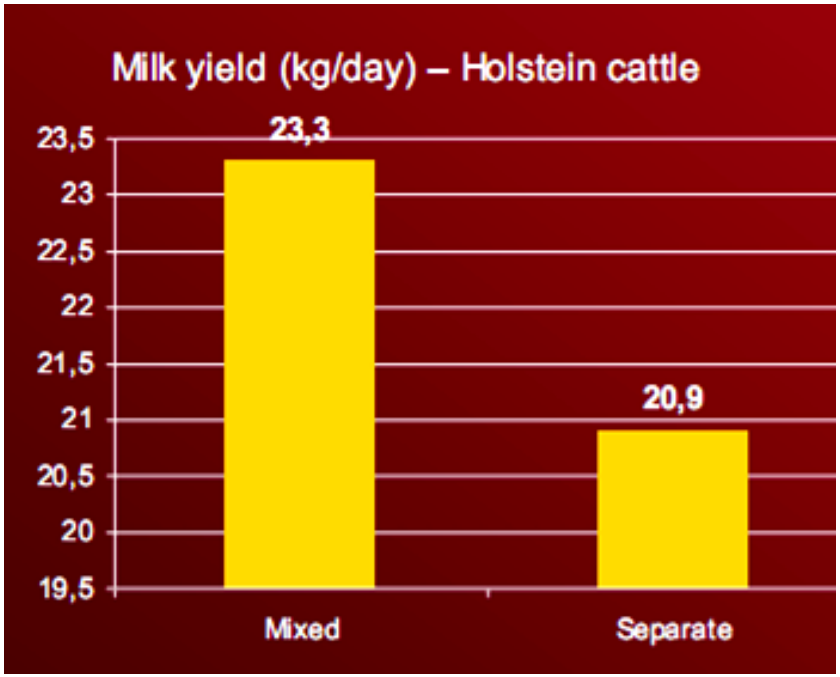
FEEDING SYSTEMS



CS = concentrate fed separated; TMR = total mixed ration; M = machine; K = knife

Vilela (2007)

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



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

Cows select cactus!

Click on the image to open video

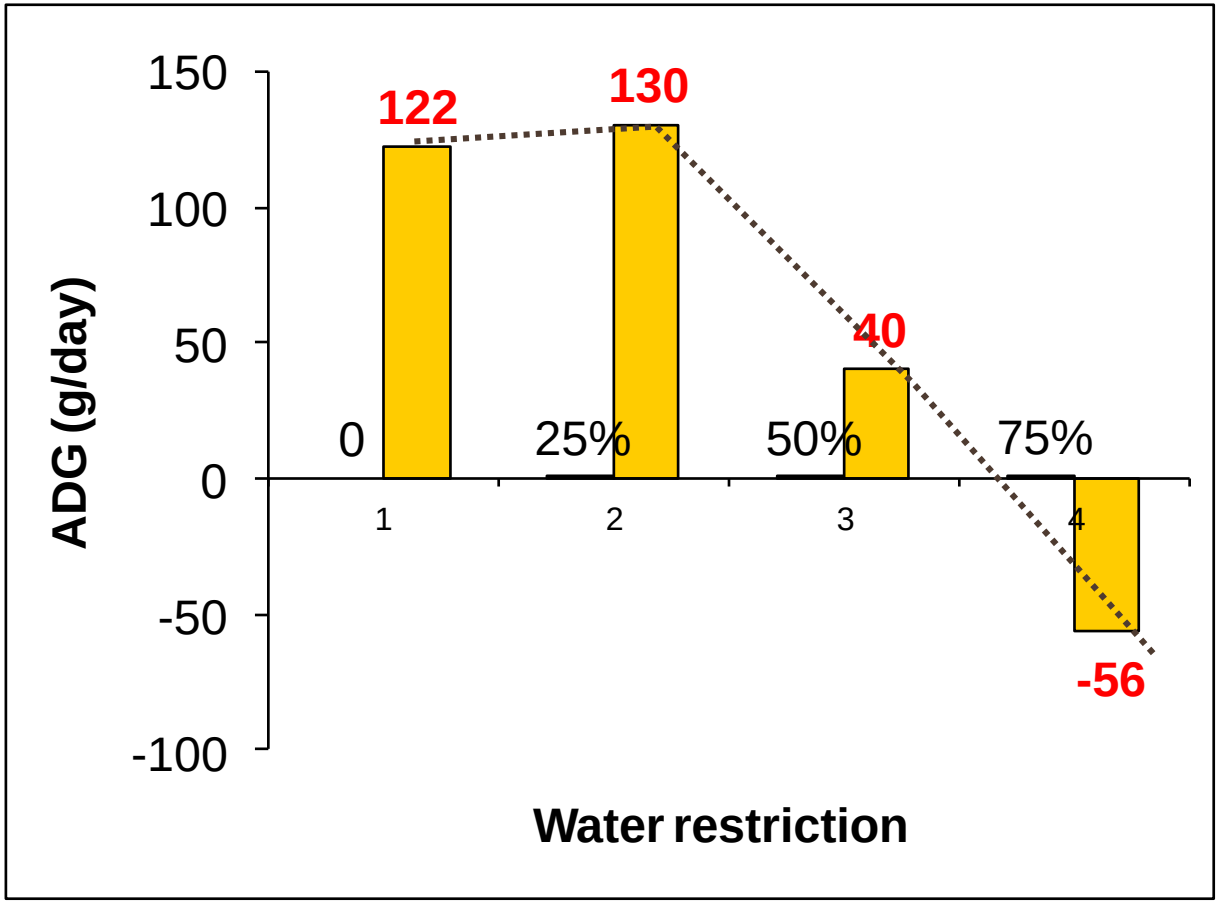
Wasted fruits in feed blocks

LAMBs (Chermiti & Ferchichi, 2000)

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

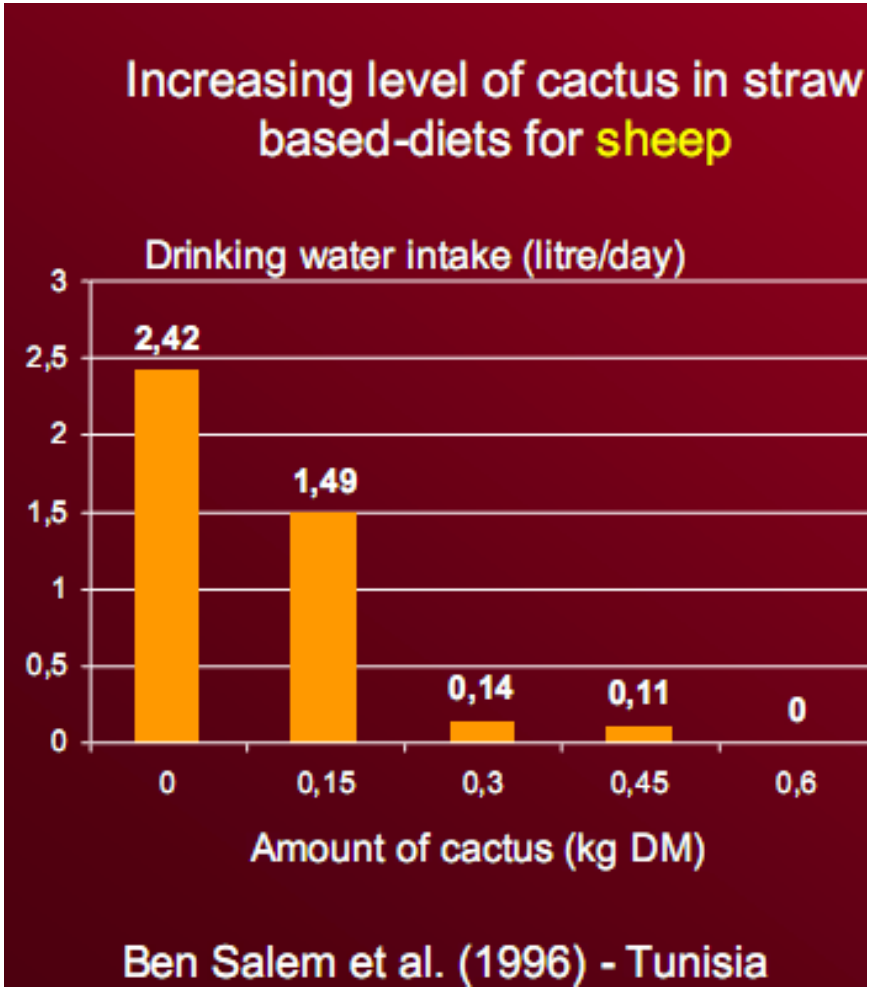
Water intake

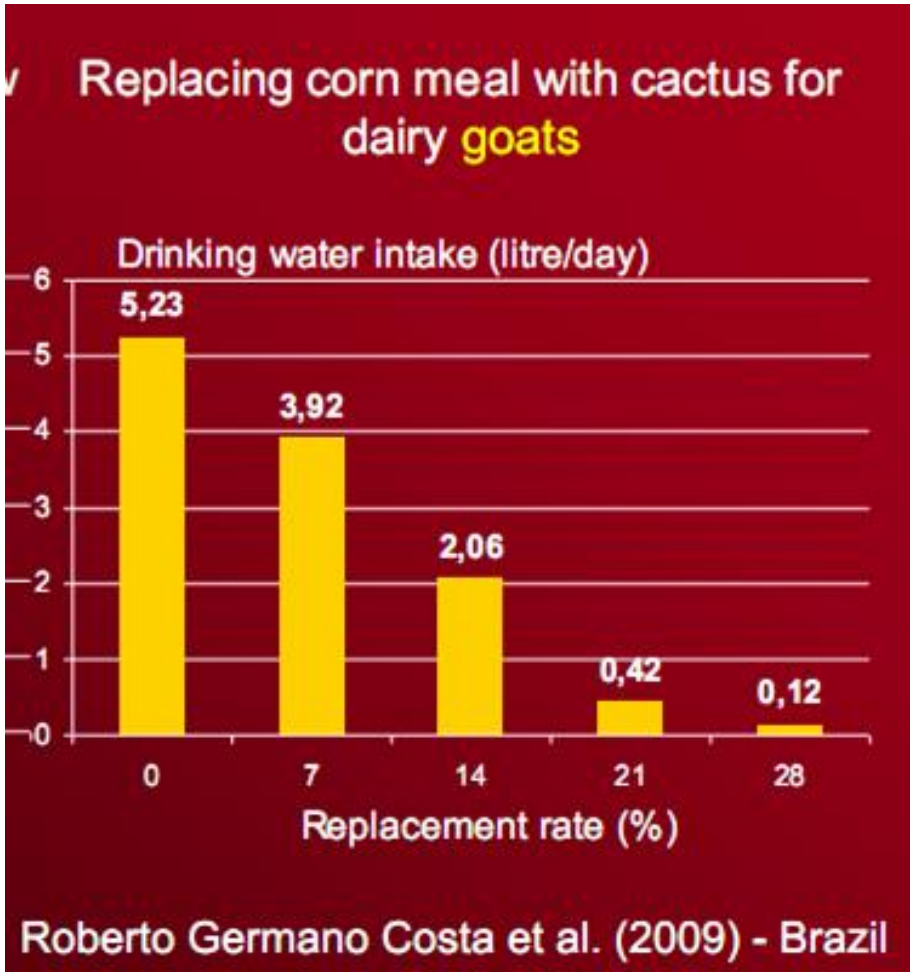
Effect of water restriction on sheep performance



Ben Salem & Abidi, 2009

Cactus helps solving watering problems in arid areas





Cactus is an important source of water

Bispo et al (2007)

Opuntia in replacement of Elephant grass hay - Sheep

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)

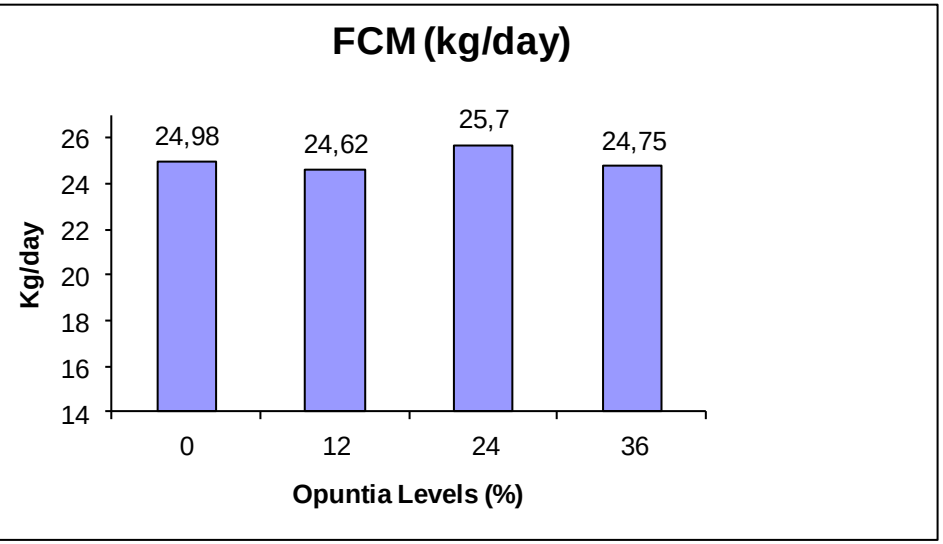
NDF forage - Minimum	NDF diet - Minimum	ADF diet - Minimum	NFC diet - Maximum
19	25	17	44
18	27	18	42
17	29	19	40
16	31	20	38
15	33	21	36

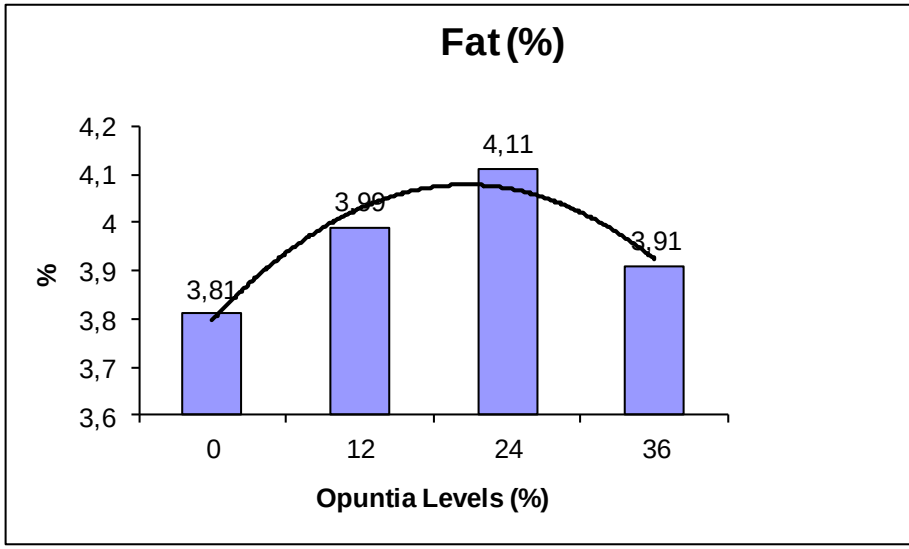
TAKE HOME MESSAGE: 50% of the fiber source should come from non-cactus roughage and NFC should be < 40%

Animal performance and dry matter intake by dairy cows fed cactus

Opuntia (% in DM)	Milk- kg/day	FS	Opuntia fresh intake Kg/day	Actual DMI (% BW)	DMI (% BW) NRC-2001	DIET NFC (%)	Authors
61.40	12.07	TMR	106.0	3.40	2.94	37.40	Pessoa, 2007
61.17	11.08	TMR	84.61	2.83	2.72	35.29	Warderley et al, 2006
44.80	12.17	TMR	86.00	3.95	3.11	26.15	Magahães et al, 2004
40.90	17.82	TMR	66.00	2.80	2.88	35.38	Melo et al., 2003
43.20	14.84	TMR	83.00	3.00	3.14	36.99	Araújo et al., 2004
39.00	22.51	TMR	90.00	3.40	3.39	39.22	Pessoa et al, 2004
39.00	21.88	IS	82.00	3.30	3.29	39.22	Pessoa et al, 2004
50.00	20.50	TMR	81.00	3.34	3.29	31.22	Cavalcanti et al,
53.40	12.36	IS	66.00	2.66	2.86	50.47*	Santos et al, 1990
51.00	12.72	IS	62.00	2.68	3.04	51.91*	Santos et al., 1998
65.54	7.10	IS	53.13	2.23	2.85	51.50*	Santos et al., 2001
36.00	24.75	TMR	54.00	3.20	3.40	40.68	Wanderley et al., 2002

Opuntia in replacement of Sorghum silage

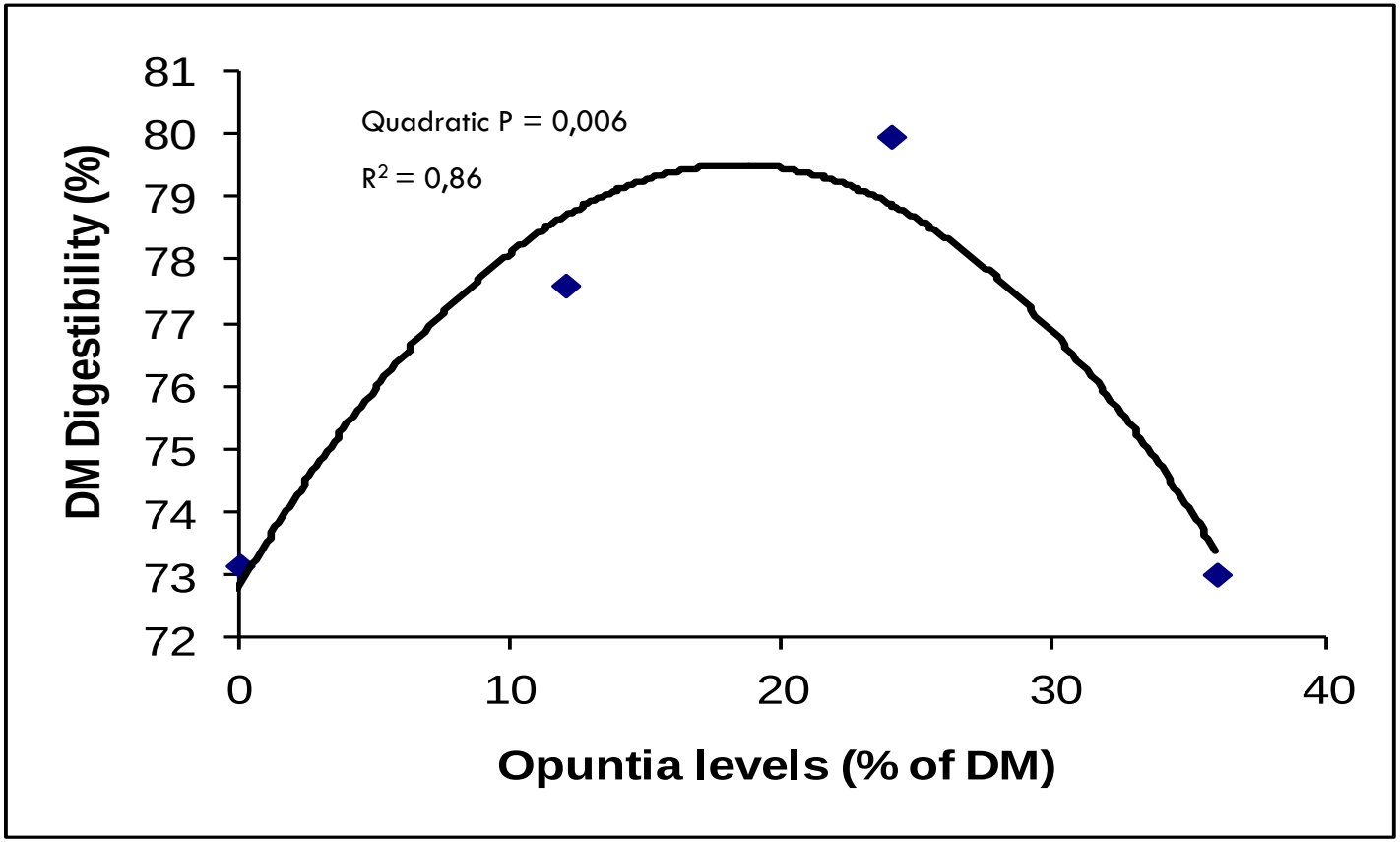




Fat Max= 4.08
(42% of NFC)

Wanderley et al. (2002)

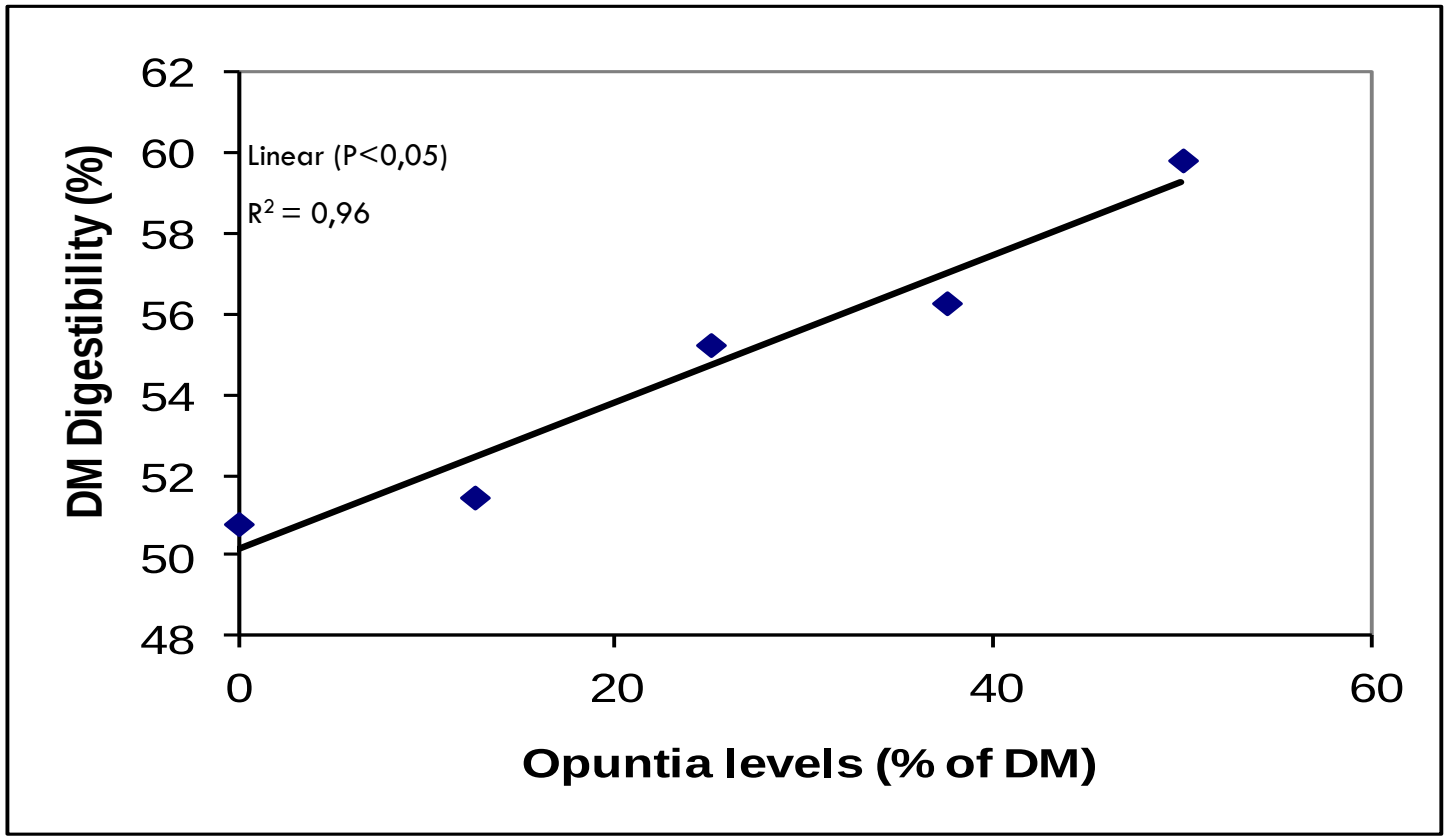
Opuntia in replacement of Sorghum silage – Dairy Cows



Andrade (2001)

- Maximum digestibility – 79% and 17.13% of Opuntia
- (NFC 40.94%)

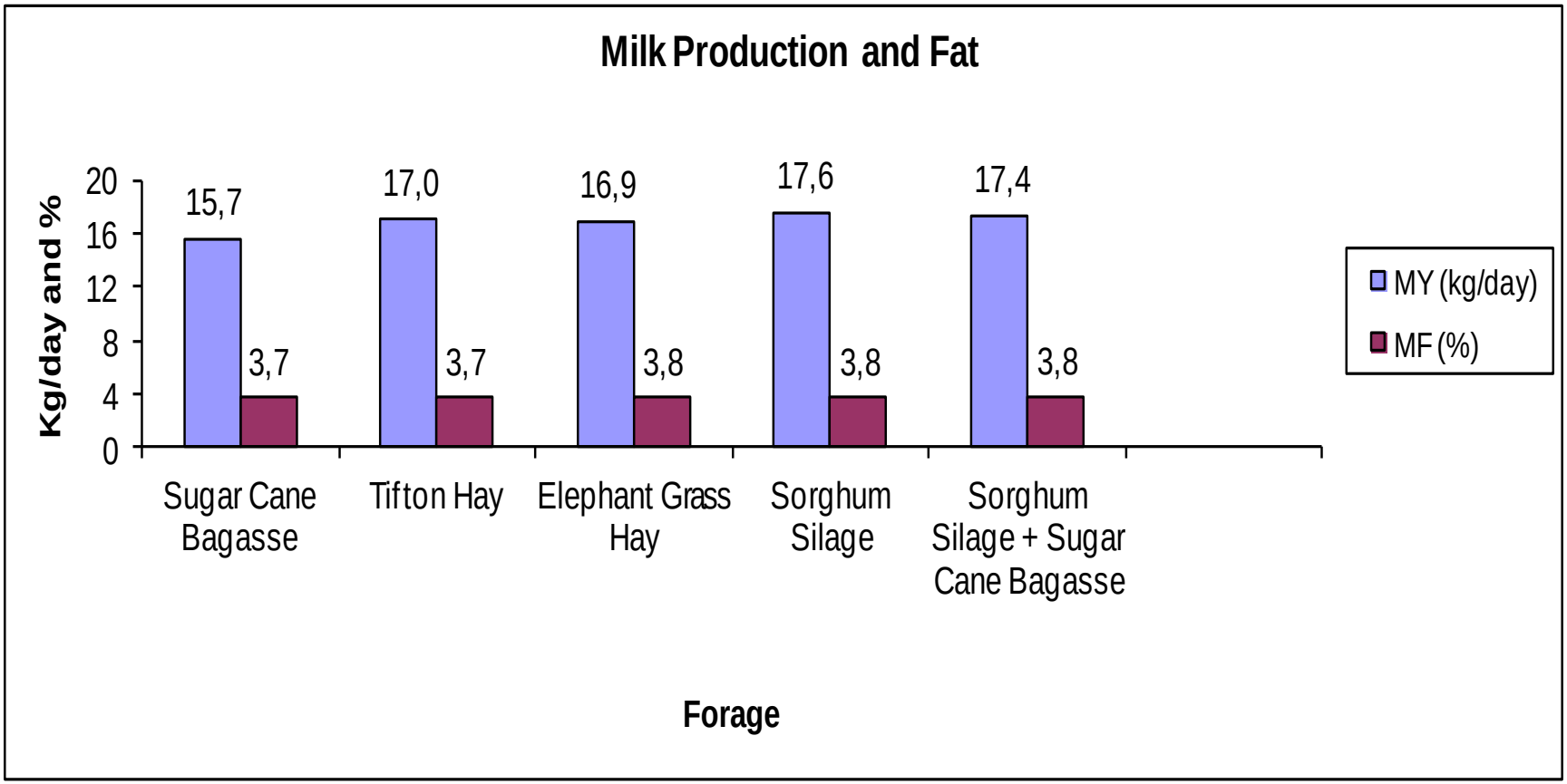
Opuntia in replacement of Tifton hay – Dairy cows



Cavalcanti (2005)

•NFC reached 38.2%

Opuntia (50% of DM) associated with different forages - Dairy Cows



Silva (2006)

Cactus replacing concentrate feeding

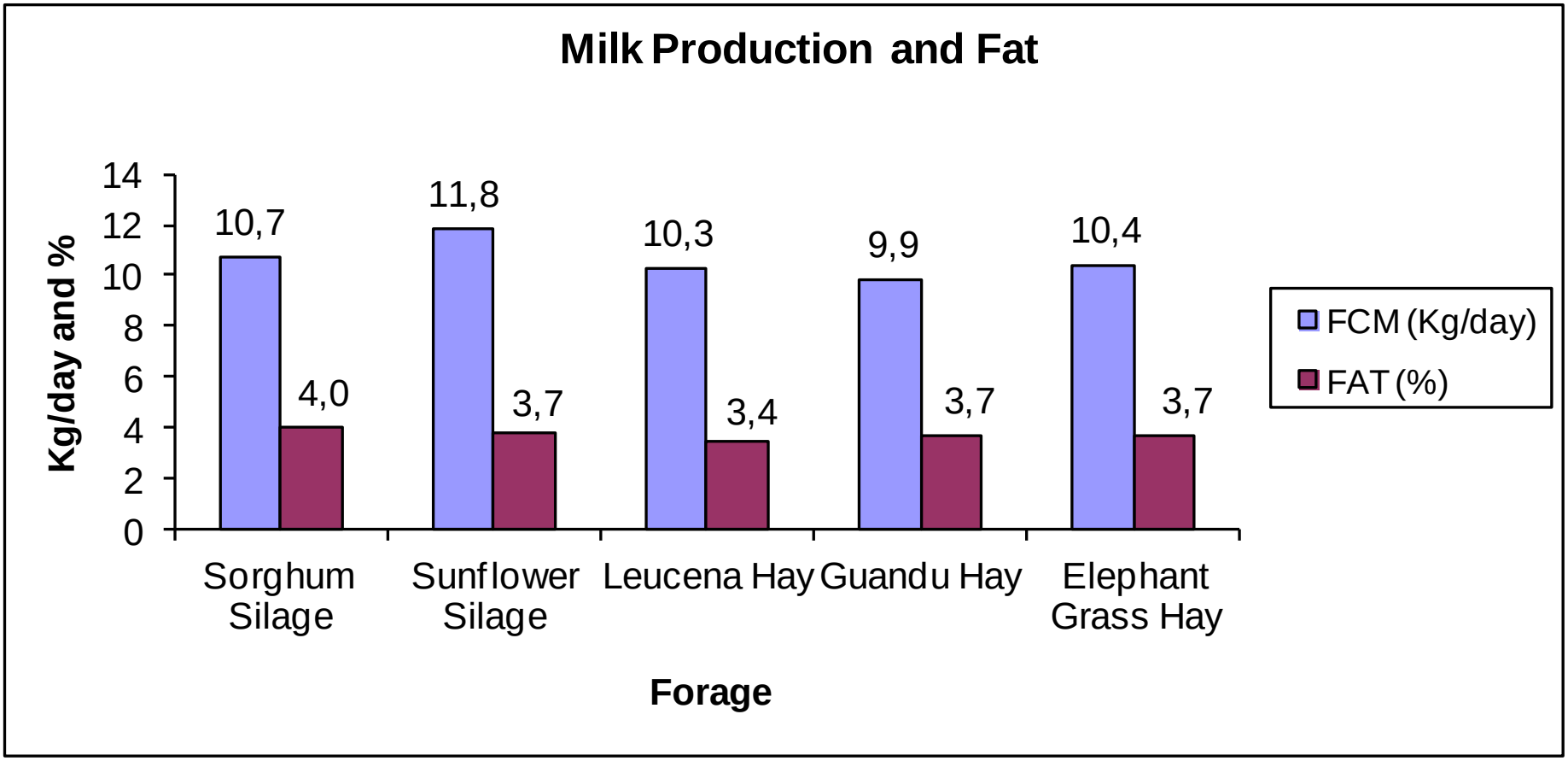
Many farmers rely on expensive concentrate feeding

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

Target association of drought tolerant species to meet livestock needs in arid areas (Ben Salem et al., 2004)

Energy	Barley	Barley	Cactus	Cactus
Protein	Soybean	Atriplex	Soybean	Atriplex
Microbial N (g/kg DOMI)	3.5b	3.2b	8.3a	11.4a
ADG (g/d)	108a	59c	119a	81b

Weaned lambs fed on straw

Concluding remarks

Concluding remarks

- Cactus is an important forage option to semiarid regions.
- 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.
- Limit in the diet is based on NFC.

Concluding remarks

- Cactus processing may improve DM intake and animal performance.
- Mixed rations should be the feeding option.
- Cactus replaces partially cereal grains and reduces feeding cost.
- Urea + cactus may be one important option to reduce soybean use as concentrate feeding.

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 to the semiarid environment makes more sense than changing the enviroment...

Thank you!