Cactus holds promises as a tool to improve the productivity & sustainability of livestock-based production systems under the climate change context

Hichem Ben Salem
INRAT - Tunisia

Ali Nefzaoui
ICARDA

VIIth International Congress on Cactus Pear & Cochineal – Agadir, Morocco – October 17-22, 2010
Not concerned with this talk

CONCERNED
Outline

- Livestock – Importance & Threats.
- Mutations of the production systems.
- Merits & better use of cactus.
- Conclusions & recommendations.
Livestock

- Key to security for many smallholder farmers.
- Indicator of wealth.
- Social, economical & environmental roles
- Better adaptation of sheep & goats to semiarid cond.

Sustainability?

- Rangeland degradation
- Biofuel industry
- Global warming
- Prices of concentrate feeds

Consumers

- No antibiotics for animals
- No chemicals in feeds
- Dietetic meat & milk
Climate change is threatening the sustainability of livestock production systems.
How Climate Change may affect livestock production systems?

<table>
<thead>
<tr>
<th>Water</th>
<th>Increasing water scarcity will affect feed availability and modify range use pattern (Thornton &amp; Herrero, 2008).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeds</td>
<td>Increased prices, Changes in land use</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>CC will accelerate the loss of genetic resources (Ehrenfeld, 2005).</td>
</tr>
<tr>
<td>Rangeland</td>
<td>Changes in primary productivity, Increase of rangeland area</td>
</tr>
<tr>
<td></td>
<td>Change in botanical composition (legumes vs. grasses, browse vs. grassland, changes in quality plant material (Thornton &amp; Herrero, 2008).</td>
</tr>
<tr>
<td>Livestock</td>
<td>Increase of diseases, heat stress, decrease of productivity</td>
</tr>
</tbody>
</table>
Outline

- Livestock – Importance & Threatness
- Mutations of the production systems.
- Merits & better use of cactus.
- Conclusions & recommandations.
Diet's composition of ruminants: (1974-1994)

Key:
AF = Afghanistan, AL = Algeria, EG = Egypt, ET = Ethiopia, IN = Iran, IQ = Iraq, J = Jordan, LN = Lebanon, LY = Libya, M = Morocco, OM = Oman, P = Pakistan, SA = Saudi Arabia, SU = Sudan, SY = Syria, TN = Tunisia, TK = Turkey, Y = Yemen.

Nordblom et al. (1997)
Rangelands: decreasing area and productivity: Causes of desertification …

<table>
<thead>
<tr>
<th>Regions/countries</th>
<th>Over-cropping</th>
<th>Over-grazing</th>
<th>Fuel-wood collection</th>
<th>Salinization</th>
<th>Urbanization</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>NENA Region</td>
<td>50</td>
<td>26</td>
<td>21</td>
<td>2</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Sahel and East Africa</td>
<td>25</td>
<td>60</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Central Asia</td>
<td>10</td>
<td>62</td>
<td>-</td>
<td>9</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>USA</td>
<td>22</td>
<td>73</td>
<td>-</td>
<td>5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Australia</td>
<td>20</td>
<td>75</td>
<td>-</td>
<td>2</td>
<td>1</td>
<td>-</td>
</tr>
</tbody>
</table>

Values are expressed as % of the total “desertified” area in the corresponding region.

Le Houérou (1996)
Deep changes in the pastoral & agropastoral systems

- Dismantlement of traditional organizations
- Privatization of communal rangelands
- Regression of animal mobility
- Reliance on supplemental feed
- Mechanization
- Inequity between poor and rich herders

In some countries, drought is not an event, but the perception of drought changed (Previous vs recent generations)

Nefzaouï & Ben Salem (2009) Tunisia
Tendencies of major drought strategies in Chénini agropastoral community, Southern Tunisia (M&M III/ Sghaier et al., 2008)

Sustainable livelihood approach (SLA) timelines – a tool for exploring dynamics of agropastoral systems & livelihoods
Feeding: major constraint for livestock production & sustainability

- Scarcity and fluctuant availability of feed resources
- Discordance between increasing flock sizes and nutrient requirements and feed availability
- Major part of livestock flocks is raised in low fodder potential areas

Promote and better use of local feed resources
Manipulation of feed resources & animal

Feed resources
- Breeding programs (drought and/or salt-tolerant plant species)
- Increase forage production (fodder shrubs, cactus, etc.)
- Better use of local feed resources
  - Targeted supplementation
  - Alkali treatment of straws (urea, ash, etc.)
  - Ensiling AGIBPs
  - Feed blocks
  - AGIBPs-based pellets
- Breeding – adapted breeds
- Rumen manipulation (e.g. tannins, saponins)
- Rumen fluid transfer from adapted to non adapted animals

Animal
- Breeding – adapted breeds
- Rumen manipulation (e.g. tannins, saponins)
- Rumen fluid transfer from adapted to non adapted animals
- Animal manipulation
  - Foetal programming
  - Behavior (Early experience)
Technologies transferred in WANA

- Alley-cropping (cereal/shrub)
- Straw treatment
- Feed blocks (+/-)
- Cactus, shrubs, ...
- Adapted plant species
- Management

Adoption ????

Rangeland management

Alley-cropping (cereal/shrub)
Outline

• Livestock – Importance & Threatness
• Mutations of the production systems.
• Merits & better use of cactus.
• Conclusions & recommendations.
Multipurpose plant:
Forage – fruits – food industry
Pharmaceutical industry…. High in sugars – Vit. A
Mucilage - pectins

De Kock (1980) – South Africa
Cactus fixes CO2 as malic acid and releases O2 during the night to prevent water losses through transpiration.

Malic acid is decarboxylated & the released CO2 is converted into glucose via photosynthetic action during the day when stomata are closed.

Malic acid reduces methane production in the rumen

Could cactus contribute to reduce GHG emissions by livestock ????
Tunisia (30 – 100 Tons /ha)

Brazil (200 – 260 Tons /ha)

Paraiba – Joa Pesoa
Breeding programs for disease control and to improve fodder potential of cactus by IPA – Arcoverde in Brazil (my visit July 2008)
Farmers in Arcoverde region (Brazil) are happy with the use of cactus cladodes in goat & dairy cattle feeding.

Complete Mixed Diet

- Cactus 60%
- Fibrous feed (hay) 20%
- Concentrate 20%

Milk production: 8 liters/goat/d
25 liters/cattle/d
Better use of cactus

Nitrogen supplementation of cactus-diets (sheep)

D1: Tef straw + 172 g cactus
D2: D1 + 145 g cotton seed cake
D3: D1 + 149 g peanut cake

Degu et al. (2009) - Ethiopia
Better use of cactus

Mixing ingredients vs. separate ingredients

Milk yield (kg/day) – Holstein cattle

Diet: Cactus (39%) + Sorghum silage (31%) + Concentrate (30%)

Pessoa et al. (2004) - Brazil
Cactus vs. Alfalfa hay in mixed diets for finishing lambs

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Energy intake (Mcal/d)</th>
<th>N intake (g/d)</th>
<th>Daily gain (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay</td>
<td>12.0</td>
<td>-</td>
<td>370</td>
</tr>
<tr>
<td>Cactus</td>
<td>-</td>
<td>20.0</td>
<td>270</td>
</tr>
<tr>
<td>Sorghum grain</td>
<td>43.2</td>
<td>42.2</td>
<td>40.7</td>
</tr>
<tr>
<td>Corn grain</td>
<td>22.0</td>
<td>19.6</td>
<td>32.1</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>14.0</td>
<td>11.0</td>
<td></td>
</tr>
<tr>
<td>Mineral premix</td>
<td>8.8</td>
<td>7.2</td>
<td></td>
</tr>
</tbody>
</table>

Pinos-Rodriguez et al. (2007) - Mexico
Tegegne et al. (2005) - Ethiopia

Better use of cactus

Urea-treated straw in cactus diets for sheep

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Urea-treated straw in cactus diets for sheep
Replacing corn meal with cactus for dairy goats
(0, 7, 14, 21 and 28%)

- No effect on milk production (1.5 – 1.63 kg/day)
- Linear decrease of milk fat (%)

Cactus alleviates feeding cost
• Target association of drought tolerant species

Weaned lambs fed on straw

<table>
<thead>
<tr>
<th></th>
<th>Energy</th>
<th>Barley</th>
<th>Barley</th>
<th>Cactus</th>
<th>Cactus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>Soyabean</td>
<td>Atriplex</td>
<td>Soyabean</td>
<td>Atriplex</td>
<td></td>
</tr>
<tr>
<td>Microbial N (g/kg DOMI)</td>
<td>3,5 b</td>
<td>3,2 b</td>
<td>8,3 a</td>
<td>11,4 a</td>
<td></td>
</tr>
<tr>
<td>Growth (g/d)</td>
<td>108 a</td>
<td>59 c</td>
<td>119 a</td>
<td>81 b</td>
<td></td>
</tr>
</tbody>
</table>

Ben Salem et al. (2004) - Tunisia
**Impact of cactus on product quality**

**Meat quality of kids**  
Zouaghi et al. (2005) - Tunisia

Diet 1: Oat hay (600 g) + Soybean meal (200 g) + Cactus
Diet 2: Oat hay (600 g) + Concentrate (600 g)

- No effect on PUFA, MUFA & SFA
- CLA increased in the meat of cactus-kids

**Meat quality of lambs**  
Vasta et al. (2006) - Tunisia

Diet 1: Silage (cactus-olive cake-wheat bran) + Soybean meal (200 g) + Cactus
Diet 2: Oat hay + Concentrate

- No effect on PUFA & MUFA
- Silage decreased SFA
C18:3 in meat

Abidi et al. (2010) - Tunisia
Cactus vs Barley on reproductive traits in ewes

Barbarine ewes: Late gestation-early suckling

Diet 1: Oat hay + barley + Soybean meal
Diet 2: Oat hay + cactus + Soybean meal

No effect on:

• Colostrum production
• Colostrum immunoglobulin G (160 vs 149 g/liter)
• Milk yield at 30 days (1030 vs 1041 g/day)
• Live weight of lambs at 30 days of age
• Ovarian activity at 30 days from lambing
Rumen manipulation with plant secondary metabolites

• Condensed tannins
  • Present in herbaceous & woody species (Sulla, acacia,..)
  • Bind to proteins in the rumen
  • Reduce protein degradation
  • When proteins >> requirements (increased performance)
  • Detrimental effect when dietary protein low
Supplementing cactus with quality proteins

Ben Salem et al. (2002) - Tunisia

Cactus intake (g DM/day)

- D1: 319
- D2: 384
- D3: 498
- D4: 663
- D5: 683
- D6: 551

Daily gain of lambs (g)

- D1: -14
- D2: -17
- D3: 79
- D4: 75
- D5: 102
- D6: 82

Supplementing cactus with quality proteins:
- Urea
- Soybean
- Treated-Soybean
- Soybean + acacia 1
- Soybean + acacia 2
Rumen manipulation with saponins

- Glycosides of aglycone linked to sugar
- Detergent action kills rumen protozoa
  - Less ammonia in the rumen
  - Enhance the flow of microbial proteins from the rumen
  - Increase the efficiency of feed utilization
- Other effects
  - Increase permeability of the intestinal mucosal cells
  - Reduce methane production
Local sources of saponins

*Trigonella foenum-graecum* (4% sap.)

*Agavae americana* (8% sap.)
Positive effects of Fenugreek saponins

**Hay + concentrate**

Daily gain of lambs (g)

- Control
- + 30 g FG

H. Ben Salem (unpublished)

**Barley silage + hay + concentrate**

Ewes Milk (ml/day)

- Control
- + 45 g FG

Ben Salem & Othmane (unpublished)

What about cactus-based diets?
- **Alley-cropping technology**
  Alary & Nefzaoui (2006) - Tunisia

<table>
<thead>
<tr>
<th>Treatment</th>
<th>straw+ grain (T/ha)</th>
<th>Grain (T/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cactus+ barley crop</td>
<td>6.65</td>
<td>2.23</td>
</tr>
<tr>
<td>Barley crop</td>
<td>4.24</td>
<td>0.82</td>
</tr>
</tbody>
</table>
Importance of water to livestock

What do we know?

Water balance & composition

- **INTAKE**
  - Drink: Water in food (5-90%)
  - Metabolic water (5-10%)

- **BODY WATER**
  - Intercellular
  - Intracellular
  - Fat

- **GUT WATER**

- **SWEAT & PANT**

- **FAECES** (18-25%)

- **URINE** (30-35%)

- **FOETUS**

- **MILK** 50%

The oxidation of organic nutrients during metabolic processes in the body leads to the formation of water (metabolic water) from the hydrogen present.
Importance of water to livestock

- Medium in which all chemical reactions in the body take place
- Acts as:
  - An ideal lubricant to transport feed
  - An aid in excretion
  - A regulator of body temperature
  - A buffering agent to regulate pH of body fluids

A loss of one-tenth of the water from the body means death.
But, animals may lose nearly all the fat and about 50% of the protein of the body and survive.
### Water restriction

Barbarine lambs tolerate moderate water restriction

<table>
<thead>
<tr>
<th>Water allow.</th>
<th>DMI (g/Kg W(^{0.75}))</th>
<th>OM dig. ( % )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ad lib</td>
<td>89.2</td>
<td>73.4</td>
</tr>
<tr>
<td>- 25%</td>
<td>84.8</td>
<td>73.0</td>
</tr>
<tr>
<td>- 50%</td>
<td>71.6</td>
<td>75.4</td>
</tr>
<tr>
<td>-75%</td>
<td>59.5</td>
<td>78.0</td>
</tr>
<tr>
<td>Signif.</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Contrast</td>
<td>L</td>
<td>L</td>
</tr>
</tbody>
</table>

**Growth rate (g/d)**

<table>
<thead>
<tr>
<th>Water allowance</th>
<th>Growth rate (g/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ad lib</td>
<td>122</td>
</tr>
<tr>
<td>-25%</td>
<td>130</td>
</tr>
<tr>
<td>-50%</td>
<td></td>
</tr>
<tr>
<td>-75%</td>
<td></td>
</tr>
</tbody>
</table>

**Microbial N supply (g/kg W\(^{0.75}\))**

<table>
<thead>
<tr>
<th>Water allowance</th>
<th>Microbial N supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ad lib</td>
<td>18</td>
</tr>
<tr>
<td>-25%</td>
<td>16</td>
</tr>
<tr>
<td>-50%</td>
<td>14</td>
</tr>
<tr>
<td>-75%</td>
<td>12</td>
</tr>
</tbody>
</table>

Ben Salem & Abidi (2009) - Tunisia
Cactus could resolve watering problem in arid areas

Increasing level of cactus in straw-based diets for sheep

Drinking water intake (litre/day)

0 0,15 0,3 0,45 0,6 0 1 1,5 2 2,5 3 3,5 4 4,5 5 5,5 6

Ben Salem et al. (1996) - Tunisia

Replacing corn meal with cactus for dairy goats

Drinking water intake (litre/day)

0 0,15 0,3 0,45 0,6

0 7 14 21 28

Replacement rate (%)

0 1 2 3 4 5 6

Roberto Germano Costa et al. (2009) - Brazil
Outline

- Livestock – Importance & Threatness
- Mutations of the production systems.
- Merits & better use of cactus.
- Conclusions & recommandations.
• Livestock agriculture is very sensitive to resource competition.

• Competition for water, land and feed will increase at the same time as demand is rising.

• This will increase the risk of insecurity of supply and possibly reduce food safety.
• Develop drought mitigation strategies (long term)
• Build up local fodder reserves “cost-effective and environmentally friendly tools”

• Cactus, a promising fodder plant
  • Source of energy.
  • Needs appropriate supplementation with protein sources
  • Reduces feeding cost.
  • Solution for livestock watering.
  • No detrimental effect on productive and reproductive performances.
  • No detrimental effects on product quality
Further research on Cactus

- Protein supply.
- Tanins and saponins administration.
- Impact on ruminal bacteria & protozoa.
- Cactus in complete mixed diets.
- Effect of malic acid in cactus on microflora and methanogenesis.
- The fate of oxalates.
- Effect on reproduction career of male and female ruminants.
• „Cactus - camel of the plant"
• Physiological mechanisms to cope with harsh conditions