Improvement of grasslands in dry areas of Mediterranean region

Claudio Porqueddu and Rita Melis

CNR - Institute for Animal Production System in Mediterranean Environment

Sassari (Sardinia - Italy)
Outline

• Introduction

• Grassland-based farming systems typologies

• Practices to improve forage self-sufficiency of Med farms

• Improving research impact on farming systems

• Final remarks
The most important climate trait of Med areas is the concentration of rainfall between autumn and spring, with a relatively mild winter season, and its total absence during hot summer, associated to a large intra- and inter-annual variability.
Potential Mediterranean grassland production

Med grasslands show a low production compared to the other European grasslands

(Huyghe et al., 2014)
Grassland-based Farming Systems in Med Countries

A huge variety of farming systems can be found

**SPAIN**

**Silvo-pastoral systems**

**PORTUGAL**

Dehesa & Montado types
Grassland-based Farming Systems in Med Countries

Agro-pastoral systems

Prygana type

GREECE

FRANCE
Grassland-based Farming Systems in Med Countries

Mixed cereal-livestock farming systems

Permanent grasslands confined to the marginal soils
Farming Systems typologies: Sardinia as case study

Landscape is a rich mosaic of feed resources/habitats

90% LFA – 60% permanent grasslands – 3 million dairy sheep
## Contribution of grassland in the animal diet in different Sardinian pedoclimatic zones

<table>
<thead>
<tr>
<th>Pedoclimatic zones</th>
<th>AH</th>
<th>AL</th>
<th>GH</th>
<th>GL</th>
<th>BH</th>
<th>Average</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. sheep farms (36 in total)</td>
<td>5</td>
<td>6</td>
<td>4</td>
<td>10</td>
<td>11</td>
<td>7.2</td>
<td>8.7</td>
</tr>
<tr>
<td>Stocking rate (ewes/ha)</td>
<td>9.1</td>
<td>8.7</td>
<td>12.7</td>
<td>4.3</td>
<td>5.6</td>
<td>7.1</td>
<td>46.3</td>
</tr>
<tr>
<td>Milk yield (kg/head)</td>
<td>193</td>
<td>190</td>
<td>188</td>
<td>175</td>
<td>106</td>
<td>157</td>
<td>23.3</td>
</tr>
<tr>
<td>Hay (kg/head)</td>
<td>41</td>
<td>181</td>
<td>50</td>
<td>13</td>
<td>68</td>
<td>66</td>
<td>98.2</td>
</tr>
<tr>
<td>Concentrate (kg/head)</td>
<td>101</td>
<td>90</td>
<td>152</td>
<td>64</td>
<td>120</td>
<td>101</td>
<td>32.7</td>
</tr>
<tr>
<td>Total Net Energy req. (FU)</td>
<td>411</td>
<td>409</td>
<td>408</td>
<td>399</td>
<td>354</td>
<td>388</td>
<td>6.1</td>
</tr>
<tr>
<td>Hay contribution (FU)</td>
<td>21</td>
<td>91</td>
<td>25</td>
<td>7</td>
<td>34</td>
<td>33</td>
<td>98.2</td>
</tr>
<tr>
<td>Concentrate contribution (FU)</td>
<td>81</td>
<td>72</td>
<td>122</td>
<td>51</td>
<td>96</td>
<td>81</td>
<td>32.7</td>
</tr>
<tr>
<td>Grazed herbage contribution (FU)</td>
<td>310</td>
<td>247</td>
<td>261</td>
<td>342</td>
<td>224</td>
<td>274</td>
<td>17.5</td>
</tr>
</tbody>
</table>

**Grazed herbage contribution (% of total NE requirements)**

<table>
<thead>
<tr>
<th></th>
<th>AH</th>
<th>AL</th>
<th>GH</th>
<th>GL</th>
<th>BH</th>
<th>Average</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>60</td>
<td>64</td>
<td>85</td>
<td>63</td>
<td>71</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

Molle *et al*., unpublished data
Open question

How to increase sustainability of Mediterranean grassland-based farms?

- Valorisation of products (added value)
- Direct compensation of ecosystem services
- Grassland profitability (primary production)
- Mitigation of seasonality and increasing forage self-sufficiency

Sustainability and resilience
Mitigation of seasonality and increasing forage self-sufficiency of Med farms

Problem with natural/semi-natural pastures: matching animal requirements with grassland forage availability

Daily growth rate of a Mediterranean semi-natural pasture

Grassland growth (kg ha$^{-1}$d$^{-1}$)

- Perennial species
- Integration with annual forage crops
- Perennial species
- Hay
- Shrubs/trees
- Stubbles
- Transhumance

OCT  NOV  DEC  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP
Grassland fertilisation

Pasture DMY (t ha\(^{-1}\)) in six sites (average of 5 years) measured with the method of Corrall and Fenlon (1978). From Bullitta and Caredda (1982)

<table>
<thead>
<tr>
<th>Site</th>
<th>Altitude (m a.s.l.)</th>
<th>Type of soil</th>
<th>DMY (t ha(^{-1}))</th>
<th>DM %</th>
<th>Extension of forage availability (in weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not fertilised</td>
<td>Fertilised</td>
<td></td>
</tr>
<tr>
<td>BONASSAI</td>
<td>80</td>
<td>Limestone</td>
<td>4.23</td>
<td>8.23</td>
<td>95</td>
</tr>
<tr>
<td>CHILIVANI</td>
<td>350</td>
<td>Alluvial</td>
<td>2.77</td>
<td>5.05</td>
<td>82</td>
</tr>
<tr>
<td>BADDE ORCA</td>
<td>600</td>
<td>Trachitic</td>
<td>3.13</td>
<td>5.52</td>
<td>76</td>
</tr>
<tr>
<td>PATTADA</td>
<td>650</td>
<td>Granite</td>
<td>4.44</td>
<td>6.33</td>
<td>43</td>
</tr>
<tr>
<td>CAMPEDA</td>
<td>650</td>
<td>Basaltic</td>
<td>3.92</td>
<td>6.41</td>
<td>63</td>
</tr>
<tr>
<td>S. ANTONIO</td>
<td>650</td>
<td>Basaltic</td>
<td>2.39</td>
<td>5.38</td>
<td>122</td>
</tr>
</tbody>
</table>

Fertilisation: 100 kg P\(_2\)O\(_5\) ha\(^{-1}\), 50 + 50 kg N ha\(^{-1}\)
Use of self-reseeding annual legumes

Pastoral annual legumes with hard seeds for permanent pastures

- Trifolium subterraneum
- Trifolium resupinatum
- Medicago polymorpha
- Ornithopus compressus
- Biserrula pelecinus

Drought escape is the main adaptive strategy that exhibit for surviving during the dry period as seed

High production and tolerance under heavy grazing
**Use of perennial legumes for rainfed grasslands**

- Drought tolerant
- Flexibile use (grazing/ hay)
- Presence of beneficial secondary compounds
- Multi-use (i.e. honey production)

**Sheep grazing on lucerne**

**Sulla coronaria**

**Onobrychis viciifolia**
Plants containing condensed tannins (<5%)

Beneficial effects
- Lower protein degradation rate in the rumen
- Higher amino acid absorption
- Decrease of dependence on pharmaceutical treatments and avoidance of helminths resistance
- Higher animal production
- Lower enteric CH$_4$ generation

Sheep grazing on sulla pasture in Sardinia

Table 3
An illustration of changes in emissions intensity (Ei; CH$_4$/kg live weight gain) in sheep fed diets of varying quality.

<table>
<thead>
<tr>
<th>Dietary ME (MJ/kg DM)</th>
<th>Forage</th>
<th>Gain (g/d)</th>
<th>Methane (g/kg DM intake)</th>
<th>Feed:gain ratio (kg DM intake/kg gain)</th>
<th>Ei (g/kg gain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0</td>
<td>Ryegrass pasture</td>
<td>100</td>
<td>24.0</td>
<td>13.6</td>
<td>300</td>
</tr>
<tr>
<td>11.0</td>
<td>Ryegrass pasture</td>
<td>150</td>
<td>22.0</td>
<td>9.4</td>
<td>210</td>
</tr>
<tr>
<td>12.0</td>
<td>Ryegrass pasture</td>
<td>200</td>
<td>21.0</td>
<td>7.5</td>
<td>160</td>
</tr>
<tr>
<td>11.5</td>
<td>Lucerne</td>
<td>250</td>
<td>20.0</td>
<td>6.7</td>
<td>130</td>
</tr>
<tr>
<td>12.0</td>
<td>Sulla$^a$</td>
<td>300</td>
<td>17.5</td>
<td>6.2</td>
<td>110</td>
</tr>
</tbody>
</table>

ME: metabolisable energy; DM: dry matter.
Calculated CH$_4$ emissions per unit of liveweight gain from growing lambs fed forages with a range of feeding values (from Waghorn and Clark, 2006).
$^a$ Sulla (*Hedysarum coronarium*) contains condensed tannins.

From Waghorn and Hegarty, 2011
Perennial grasses for permanent pasture

Areas with annual rainfall over 400 mm

Phalaris aquatica

Festuca arundinacea

Dactylis glomerata

Traits: summer dormancy and high water use efficiency
Persistence in perennial grasses for permanent pasture

Average row cover (%) after 6 years. Mean values among six sites in Mediterranean environments. From Annicchiarico et al. (2013)

![Bar chart showing persistence in perennial grasses](chart.png)

Survival after summer

*Dactylis* temperate origin

*Dactylis* Med origin

Lutetia

Medly
Total and seasonal production of native grasses adapted to Mediterranean environments

Porqueddu et al. (2008)
Use of mixtures of adapted native grasses and legumes

EU Action COST 852 “Quality Legume-Based Systems for Contrasting Environments”

Species belonging to 4 functional groups:
- Grass / Legumes
- Fast establishing / Slow establishing (= annuals/perennials)

NATIVE SPECIES (Dry Mediterranean mixture)

\[ G_1 = \text{Lolium rigidum Nurra} \]
\[ G_2 = \text{Dactylis glomerata Currie} \]
\[ L_1 = \text{Medicago polymorpha Anglona} \]
\[ L_2 = \text{Medicago sativa Surigheddu} \]
## Improving forage quality using native species-based mixes

<table>
<thead>
<tr>
<th>Plot</th>
<th>CP</th>
<th>NDF</th>
<th>IVDMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2 mono</td>
<td>20.0</td>
<td>42.9</td>
<td>69.8</td>
</tr>
<tr>
<td>centroid</td>
<td>18.5</td>
<td>47.5</td>
<td>67.8</td>
</tr>
<tr>
<td>dom G2 and L2</td>
<td>18.4</td>
<td>48.0</td>
<td>67.6</td>
</tr>
<tr>
<td>dom L2</td>
<td>18.4</td>
<td>46.2</td>
<td>69.1</td>
</tr>
<tr>
<td>dom L1 and L2</td>
<td>18.1</td>
<td>47.1</td>
<td>68.1</td>
</tr>
<tr>
<td>dom G1 and L2</td>
<td>17.9</td>
<td>48.0</td>
<td>66.9</td>
</tr>
<tr>
<td>dom G2 and L1</td>
<td>17.7</td>
<td>46.8</td>
<td>68.2</td>
</tr>
<tr>
<td>dom G2</td>
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<tr>
<td>dom G1 and G2</td>
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<td>68.2</td>
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<td>46.3</td>
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<td>17.2</td>
<td>47.0</td>
<td>68.6</td>
</tr>
<tr>
<td>dom G1 and L1</td>
<td>15.8</td>
<td>46.2</td>
<td>66.8</td>
</tr>
<tr>
<td>L1 mono</td>
<td>14.8</td>
<td>42.1</td>
<td>68.1</td>
</tr>
<tr>
<td>G2 mono</td>
<td>14.3</td>
<td>59.2</td>
<td>58.5</td>
</tr>
<tr>
<td>G1 mono</td>
<td>12.9</td>
<td>47.1</td>
<td>64.7</td>
</tr>
<tr>
<td>mean mono</td>
<td>15.5</td>
<td>47.8</td>
<td>65.3</td>
</tr>
<tr>
<td>% change mono/centr.</td>
<td>19.3</td>
<td>-0.7</td>
<td>3.9</td>
</tr>
</tbody>
</table>

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G1 = *L. rigudum*

G2 = *D. glomerata*

L1 = *M. polymorpha*

L2 = *M. sativa*

1 = fast establishing species

2 = slow establishing species

Average values of 5 harvests along the year

Maltoni et al. (2007)
Involvement of stakeholders: farmers

ARIMNET - Project REFORMA   http://reforma.entecra.it/

Traits
- DMY
- Forage quality
- Interest as a crop
- Interest as feed
- Crop global value

Score ranking
1 = very poor/low
2 = poor/low
3 = sufficient
4 = high/good
5 = very high/very good
Involvement of stakeholders: farmers, advisors and researchers

Sheeptoship LIFE Project aims to develop and promote eco-innovative dairy sheep production models using Life Cycle Approach

LCA is a powerful method to provide a holistic assessment of the production processes, in terms of resources use and environmental impacts, as well as identification of hotspots at farm level

A survey on 20 representatives dairy sheep farms is being carried out in Sardinia where a model of actions and measures on climate change will be tested

http://www.sheephtoship.eu/
Involvement of stakeholders: multi-actor approach
**Take home message**

- Mediterranean grassland-based systems have a high degree of diversity and require a complex holistic multidisciplinary approach and the identification of solutions adapted to a local scale, involving also stakeholders.
Thanks for your attention!