The importance and variability of forages

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Forages- definition

Definition:
- **Forages:** Vegetative portion of plants consumed by animals
- Includes edible plant parts (traditionally excluded grain) that provide feed when grazed / harvested
- **Roughages:** Less digestible, fibrous feeds with over >18% CF including forages, byproducts and crop residues

Examples of forages
- Hay, haylage, silage, straw, fodder, browse
Forages in history

- Human existence is dependent on adequate grasslands
- Hay making is mentioned in the Bible (Proverbs 27:25) & dates back to & 750 BC. Silage making is > 3000 yr old.
- Anglo saxons produced the first recorded, enclosed meadows in Britain in AD 800.
- Crop rotation (2 yr of wheat vs 5 yr of grass) practiced in the 1400s by monks.
- Red clover was cultivated in Italy in 1550; spread to Western Europe later
Forages – Current importance

- Backbone of sustainable agriculture
- Over 3 billion ha of the earths’ land (>25%) is grazing land
- 4 billion ha (forest & woodland) have grazing potential
- Forages provide >90% of the feed energy consumed by Camels, cattle, buffalo, sheep, goats worldwide (Fitzhugh, 1978)
- Hence forages indirectly, feed the world’s population
Importance of forage

<table>
<thead>
<tr>
<th>Region</th>
<th>Permanent grassland (% as agricultural area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>84</td>
</tr>
<tr>
<td>North &amp; Central America</td>
<td>57</td>
</tr>
<tr>
<td>South America</td>
<td>82</td>
</tr>
<tr>
<td>Oceania</td>
<td>89</td>
</tr>
<tr>
<td>Asia*</td>
<td>67</td>
</tr>
<tr>
<td>Europe*</td>
<td>33</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>40</td>
</tr>
<tr>
<td>World total</td>
<td>70</td>
</tr>
</tbody>
</table>

*Excludes Russian Federation

(FAO, 1996)
The importance of forages in US

- Half a billion ha (> ½ of land area) used for grassland in US

- 56% of total land dedicated to forage production in 1977

- Even under the intensive concentrate feeding systems of ruminant animal production in the USA, forages continue to represent the single most important feed resource (Jung and Allen, 1995).

- Value of forages for feed = $24.027 billion;
  - Exceeds that for all other crops
  - Hay = $10.457 billion, corn = $18.191 billion (USDA, 1992)
Role of forages

- Provides food for **wildlife and ruminant livestock**
- **Conserves soils** by reducing erosion
- **Biofuel**
- Protects water quality; serve as water **purifiers or filters (prevents pollution)**
- **Amenity grasslands** – golf courses, stadia etc
- **Major role is for ruminant livestock nutrition**
  - Grazed
  - Conserved for winter /dry seasons feeding
Why feed forages

- Cheaper than concentrates—can be exploited for profit
- Enhances gut function and animal health (effective fiber)
- It is natural
- It is environmentally benign
  - “Where intensification of dairy production has reduced forage use, adverse environmental effects are common”
- Can improve the fatty acid profile of meat relative to a concentrate-based diet
Dietary grass:concentrate ratio (kg) effects on fatty acid (FA) percentage of beef


6:05 = 6 kg grass, 5 kg concentrate
8:01 = 8 kg grass, 1 kg concentrate
12:00 = 12 kg grass, 0 kg concentrate
# Use of forages by US livestock

<table>
<thead>
<tr>
<th>Animal</th>
<th>% of forage in ration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy cattle</td>
<td>61.2</td>
</tr>
<tr>
<td>Beef cattle on feed</td>
<td>27.6</td>
</tr>
<tr>
<td>Beef cattle at pasture</td>
<td>95.6</td>
</tr>
<tr>
<td>All beef cattle</td>
<td>83.0</td>
</tr>
<tr>
<td>Sheep and goats</td>
<td>91.1</td>
</tr>
<tr>
<td>Horses</td>
<td>72.2</td>
</tr>
<tr>
<td>Poultry</td>
<td>0.0</td>
</tr>
<tr>
<td>Hogs</td>
<td>14.7</td>
</tr>
</tbody>
</table>

* (CAST, 1980)
Why analyze forages
Factors affecting forage quality

- Plant factors
- Genotype
- Climate
- Management
- Antinutritive factors
- Storage conditions
Plant Genotype

♦ Grasses vs. legumes
  – Grasses often have more fiber, less CP, less lignin than legumes

♦ $\text{C}_4$ vs. $\text{C}_3$ grasses
  – $\text{C}_4$ grasses yield more but have greater cell wall concentrations, which reduces intake

♦ Improved vs. native cultivars.
  – Improved species have been selected for lower cell wall concentration and greater CP concentration

♦ Mutation
  – Brown mid rib corn has $\sim 1\%$ less lignin than normal corn which increases fiber digestibility
Other Plant factors

- **Anatomy**
  - Tropical (C4) grasses have more bundle sheath cells and less mesophyll, and are less digestible,
  - whereas temperate (C3) grasses have the opposite

- **Chemical composition**
  - Greater cell wall & lignin concentrations are usually associated with poorer forage quality

- **Leaf to stem ratio**
  - Thicker stems or lower leaf to stem ratios generally imply greater cell wall concentrations
Leaf Anatomy Differences

$C_3$

- Upper epidermis
- Palisade mesophyll cell
- Vein
- Bundle sheath cell
- Spongy mesophyll cell
- Lower epidermis

$C_4$

- Upper epidermis
- Mesophyll cell
- Vein
- Bundle sheath cell
- Lower epidermis

Stoma
Impact of leaf type on 48 h Digestibility

Bermudagrass (C₄)

Orchardgrass (C₃)

M = mesophyll, E = epidermis, B = parenchyma bundle sheath, S = sclerenchyma and V = vascular tissue. (Akin, 1989).
### Nutritive value of grasses and legumes

<table>
<thead>
<tr>
<th>Item</th>
<th>Bahiagrass</th>
<th>Perennial peanut</th>
<th>Pigeon pea</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>8.1&lt;sup&gt;d&lt;/sup&gt;</td>
<td>15.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>12.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.4</td>
</tr>
<tr>
<td>NDF</td>
<td>73.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>43.3&lt;sup&gt;f&lt;/sup&gt;</td>
<td>78.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.0</td>
</tr>
<tr>
<td>ADL</td>
<td>6.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>17.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.1</td>
</tr>
<tr>
<td>IVTD</td>
<td>50.7&lt;sup&gt;d&lt;/sup&gt;</td>
<td>77.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>35.1&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.1</td>
</tr>
</tbody>
</table>
Climatic factors

- **Temperature**
  - High temperatures favor cell wall deposition whereas lower temperatures favor sugar deposition
  - Sudden frosts can lead to accumulation of toxins like nitrates

- **Moisture**
  - Droughts can limit cell wall deposition and increase nitrate accumulation

- **Sunlight**
  - Inadequate photoperiod can cause senescence and sugar and N losses from plants
Joliff et al. (1979)

Seasonal variation of Bermudagrass in Texas

--- Coastcross

---- Coastal

**Graph:**
- Mean daily temperature in °C
- Monthly total precipitation in cm
- Frost dates: Nov. 13: 0°, Nov. 23: -2°, Nov. 25: -1°

**Diagrams:**
- NDF (4-week, 12-week)
- CP
- IVDMD

**Key:**
- 4-week
- 12-week
Management factors

♦ Fertilization
  – N fertilization can increase plant CP %

♦ Maturity / regrowth interval
  – Generally cell wall deposition and lignification increase with maturity / regrowth interval

♦ Cutting height, plant spacing, etc may also affect quality
Antinutritive factors

- **Tannins**
  - Plant phenolic compounds that can limit CP and nutrient availability to animals

- **Endophytes**
  - *Neotyphodium coenophialum* in alkaloids in endophyte-infested tall fescue causes fescue toxicity in cattle

- **Others** include saponins, trypsin inhibitors, gossypol, mimosine etc.
Storage conditions

- **Poor storage can cause**
  - Moisture and DM loss, heating, mold growth, spoilage, etc

- **Storage as hay**
  - Reduces vitamin A, increases vitamin D and may reduce sugars and CP

- **Storage as silage**
  - Reduces moisture, pH and sugars, increases organic acids, and makes CP more soluble
Reference

- Ch 37 in the Forages, The Science of Grassland Agriculture