Opportunities for forage improvement through the ILRI genebank

Chris Jones and Alieu Sartie

African Plant Breeding Academy,
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Overview of smallholder feeding systems

- Feed quantity and quality - a key limitation to livestock production in the tropics
  - Estimated to be 50 to 80% of total production costs
  - Particularly an issue during the dry season
- Poor quality feeds (crop residues) constitute the major component of the diet
- Pasture lands/rangelands declining in size and fertility
- Land tenure issues and lack of enabling policies
Strategies to meet feed demands

Optimizing feeding practices

• Prioritizing and targeting forage interventions using decision-support tools
• Making better use of existing feed resources
• Developing new feed and forage options
  • Exploiting inherent natural resource management characteristics
  • More and higher quality feeds and forages
Planted forages

- Increase livestock production by alleviating feed constraints/shortages
- Improve soil fertility through nitrogen fixation/leaf drop
- Reduce erosion through increased ground cover, especially on slopes
- Help control insect pests
- Provide environmental services - carbon sequestration, enhanced system water productivity
- Improve system resilience - alternative land use strategy for marginal lands and steep slopes
Livestock production benefits

- Modelling increases in milk yields in response to different interventions in Ethiopia

(Herrero et al., 2016)
Demand for forages is growing

This is linked to:

- Market intensification for milk and meat
- Global food prices making grain an expensive feed
- Feed scarcity from competition, biofuels, reducing rangelands and natural pastures and drought incidence
- Rising feed prices
- Demands for re-vegetation, soil and water management
- Alternative income generation opportunities
ILRI Facilities

- Nutrition analysis platform
  - Proximate and *in vitro* feed analysis (S Asia, E and W Africa)
  - ILRI shares NIRS equations for all key cereal and legume crops (residues and grains)
- Genebank and four field sites
- Forage Seed Unit: provides basic seeds and promote national seed systems
Qualitative trait prediction based on Near Infrared Spectroscopy (NIRS)

Physico-chemical
c. $60,000
Calibration
Validation

Non-invasive
c. 200 samples/day
>30 traits

Establishing an International NIRS feed analysis platform
The ILRI forage genebank

- A unique resource for exploring and capturing forage diversity
- 1,400 species representing over 600 genera
- Around 2,000 accessions distributed annually

<table>
<thead>
<tr>
<th>Forage type</th>
<th>Total accessions</th>
<th>Accessions under Treaty</th>
<th>Annex 1 accessions</th>
<th>Forage cultivars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Browse</td>
<td>3,720</td>
<td>3,684</td>
<td>45</td>
<td>25</td>
</tr>
<tr>
<td>Grasses</td>
<td>4,397</td>
<td>4,377</td>
<td>313</td>
<td>11</td>
</tr>
<tr>
<td>Legumes</td>
<td>10,518</td>
<td>10,440</td>
<td>2,646</td>
<td>275</td>
</tr>
<tr>
<td>Total</td>
<td>18,635</td>
<td>18,501</td>
<td>3,004</td>
<td>311</td>
</tr>
</tbody>
</table>
## Four forage field genebanks

<table>
<thead>
<tr>
<th>Site</th>
<th>Altitude (m.a.s.l.)</th>
<th>Rainfall (mm)</th>
<th>Soil</th>
<th>Compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highland (Gurd Shola)</td>
<td>2400</td>
<td>1000</td>
<td>Vertisol, rainfed</td>
<td>Tropical highland and temperate species</td>
</tr>
<tr>
<td>Mid-altitude (Bishoftu)</td>
<td>1800</td>
<td>800</td>
<td>Alfisol/Vertisol, irrigated</td>
<td>Tropical highland and temperate species</td>
</tr>
<tr>
<td>Mid-altitude (Soddo)</td>
<td>1800</td>
<td>1200</td>
<td>Acid Nitosol, rainfed</td>
<td>Acid soil adapted species</td>
</tr>
<tr>
<td>Lowland (Zwai)</td>
<td>1650</td>
<td>500</td>
<td>Sandy alkaline, irrigated</td>
<td>Tropical lowland species, especially grasses</td>
</tr>
</tbody>
</table>
Bishoftu forage field genebank
Zwai forage field genebank
ILRI Feed and forage, discovery to delivery

Germplasm

Laboratory

Delivery to producers

Characterization and evaluation

Public and private sector

Basic seed production

On-station trials

Promising genotypes

Variety registration

Promising genotypes

Farmers fields
Perennial forage grasses

Napier grass

- The major forage species for smallholder dairy in East Africa
  - High yielding lines produce 5 times more biomass than natural pastures in Tanzania\(^1\)
  - Yield shown to increase by intercropping with legumes and can be harvested 6 to 9 times per year under irrigation in Ethiopia\(^2\)
  - Smut and stunt disease resistant lines identified from the in trust collection at ILRI and being adopted by farmers

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\(^2\)Adie et al. Lessons from pilot trials with small-scale irrigated forage production in the Amhara Region: potential of integrating the perennial forage Napier grass with Desmodium and Pigeon Pea in cropping systems. The second Amhara Agricultural Forum. 16 January 2018, Bahir Dar.
Marker Assisted Selection (MAS) of Napier grass performance under drought

- Tapping into the substantial amount of variation held in the ILRI genebank collection to develop improved varieties by MAS

Cluster analysis of 104 Napier grass accessions

Manhattan plot showing marker associated with dry weight under limited water
Water use efficiency trial - assessing agronomic and nutritional characteristics

<table>
<thead>
<tr>
<th></th>
<th>leaf</th>
<th>stem</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP (%)</td>
<td>5.9 to 23.6</td>
<td>6.4 to 20.9</td>
</tr>
<tr>
<td>IVOMD (%)</td>
<td>53.7 to 68.0</td>
<td>54.1 to 73.0</td>
</tr>
<tr>
<td>ME (MJ/kg DM)</td>
<td>7.8 to 9.7</td>
<td>7.8 to 10.4</td>
</tr>
</tbody>
</table>
Creating subsets

Optimal-water

Whole trial

Water-deficit
Perennial forage grasses

Buffel grass

- One of the best pasture grasses for the Africa subtropics
  - An apomictic, perennial C4 grass
  - Good forage potential, and particularly a candidate for drought tolerance
  - Also helps to prevent soil erosion

GBS analysis of 185 accessions of the genebank collection
Agronomic and nutritional characteristics

<table>
<thead>
<tr>
<th>Wet Season</th>
<th></th>
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<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Group I (49)</td>
<td>Group II (11)</td>
<td>Group III (25)</td>
<td>Group IV (23)</td>
<td>Group V (7)</td>
<td>Group VI (10)</td>
</tr>
<tr>
<td>Y (kg/ha)</td>
<td>2378</td>
<td>3789</td>
<td>4831</td>
<td>2743</td>
<td>2328</td>
<td>4540</td>
</tr>
<tr>
<td>PH</td>
<td>71</td>
<td>94</td>
<td>102</td>
<td>84</td>
<td>84</td>
<td>114</td>
</tr>
<tr>
<td>LL (cm)</td>
<td>24</td>
<td>34</td>
<td>36</td>
<td>26</td>
<td>24</td>
<td>34</td>
</tr>
<tr>
<td>CP (%)</td>
<td>13.5</td>
<td>11.0</td>
<td>12.0</td>
<td>12.8</td>
<td>11.6</td>
<td>9.9</td>
</tr>
<tr>
<td>NDF (%)</td>
<td>69.2</td>
<td>70.2</td>
<td>71.4</td>
<td>71.0</td>
<td>72.3</td>
<td>73.9</td>
</tr>
<tr>
<td>ADF (%)</td>
<td>38.3</td>
<td>40.4</td>
<td>41.7</td>
<td>41.1</td>
<td>42.6</td>
<td>45.2</td>
</tr>
<tr>
<td>IVOMD (%)</td>
<td>72.6</td>
<td>65.6</td>
<td>70.2</td>
<td>71.5</td>
<td>66.3</td>
<td>63.0</td>
</tr>
</tbody>
</table>
Perennial forage grasses

Rhodes grass,
- A major forage in the tropics and subtropics.
- Cross-pollinating C4, with diploid and tetraploid forms, usually propagated by seed
- Known for its wide adaptability and ease of establishment

GBS analysis of 94 accessions of the genebank collection
Desho

- Well adapted and widely used in the highlands Ethiopia along with natural resource management practices
- Roots splits and forage biomass traded as source of cash
Annual forages

Oats and vetch

- Well adapted, high yielding and good quality annual forage for the highlands, widely scaled in the highlands of Ethiopia

![Bar graph showing milk yield before and after oat-vetch supplementation for local cows and crossbreds.]

- Local cows before supplementation: 57%
- Crossbreds before supplementation: 78%
- Local cows after oat-vetch supplementation: 78%
- Crossbreds after oat-vetch supplementation: 57%
Lessons learnt on forage adoption

Forage adoption and use has been slow. Adoption is improved when:

• Use of improved feeds linked to market opportunities, with on-farm multiple benefits
• Good match to production system niche
• Easy to manage and match skills of farmers
• Strong partnerships between farmers and extension
• Supported by innovation platforms, enabling policies and environment
Potential ways forward

- Opportunities are significant to improve the feed resource base in the smallholder systems
- Adoption of improved forage technologies can be accelerated if the right type of approach and technology is presented to smallholders
- Integrating improved forages with NRM efforts creates synergies
- Strong public and private investment in the feed sector and enabling policies are needed to meet feed demands
- Integrated breeding solutions: livestock, forages and crops
better lives through livestock

ilri.org

ILRI thanks all donors and organizations who globally supported its work through their contributions to the CGIAR system.