Multi-dimensional crop improvement: experiences from collaborative ILRI-ICRISAT-NARES work on sorghum in India

Michael Blümmel\textsuperscript{a}, V. Vadez\textsuperscript{b}, N. Seetharama\textsuperscript{c}, D. V. A. Tonapi\textsuperscript{c}, V Bhat\textsuperscript{c}, B. V. S. Reddy\textsuperscript{b} and C. S. Jones\textsuperscript{a}

\textsuperscript{a} International Livestock Research Institute (ILRI) Feed and Forage Program
\textsuperscript{b} International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
\textsuperscript{c} National Research Center for Sorghum now Indian Institute for Millet Research

Sorghum in the 21\textsuperscript{st} Century, Cape Town, South Africa 9-12 April 2018
Topics

- Why pay attention to stover or more generally crop residues: feed supply-demand scenarios, crop residue fodder markets

- Impact of stover fodder quality on livestock productivity: what degree of differences matter

- Exploit existing cultivar variations and targeted genetic enhancement, trade-offs

- Where to go from here
Feed resource supply - demand scenarios in India

<table>
<thead>
<tr>
<th>Feed resource</th>
<th>Contribution to overall feed resources (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greens from CRP, forests, grazing</td>
<td>8.0</td>
</tr>
<tr>
<td>Planted forages</td>
<td>15.1</td>
</tr>
<tr>
<td>Crop residues</td>
<td>70.6</td>
</tr>
<tr>
<td>Concentrates</td>
<td>6.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Deficit: feed availability versus feed requirement (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter (i.e. crop residue quantity)</td>
</tr>
<tr>
<td>Digestible crude protein</td>
</tr>
<tr>
<td>Total digestible nutrients</td>
</tr>
</tbody>
</table>

(NIANP 2012; Blümmel at al. 2014)
Yield differences in milk production between the 10% most productive farmers and the remaining 90% in India using comparable dairy genetics (Derived from VDSA-India 2013 and Blümmel et al. 2016b)
Commercial Sorghum stover trading in Hyderabad, India
Comparisons of average cost of dry sorghum stover traded in Hyderabad and average of cost of sorghum grain in Andhra Pradesh 2005 to 2005 and 2008 to 2009

Grain: stover value in sorghum traded in Hyderabad from 2004-5 and from 2008-9

Sharma et al. 2010
Relation between average digestibility and price of sorghum stover traded from 2004 to 2005

\[ y = -4.9 + 0.17x; \quad R^2 = 0.75; \quad P = 0.03 \]

Stover in vitro digestibility (%)
Stover price (IR/kg DM)

- Premium Stover “Raichur”
- Low Cost Stover “Local Yellow”

Blümmel and Parthasarathy, 2006
Why pay attention to crop residues fodder improvement at source

- Feed supply – demand scenarios underline key role of crop residues as feed sources (in most LMC)

- Fodder market surveys show high monetary value, narrowing crop residue-grain price ratios and price premiums

- Continued driving factor: more quality fodder required with shrinking natural resource basis
Impact of variations in sorghum stover fodder quality on livestock productivity

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum stover</td>
<td>50</td>
</tr>
<tr>
<td>Bran/husks/hulls</td>
<td>18</td>
</tr>
<tr>
<td>Oilcakes</td>
<td>18</td>
</tr>
<tr>
<td>Molasses</td>
<td>8</td>
</tr>
<tr>
<td>Grains</td>
<td>4</td>
</tr>
<tr>
<td>Minerals, vitamins, urea</td>
<td>2</td>
</tr>
</tbody>
</table>

Courtesy: Miracle Fodder and Feeds PVT LTD
Comparisons of feed blocks based on lower (47%) and higher (52%) digestible sorghum stover and tested with commercial dairy buffalo farmer in India

<table>
<thead>
<tr>
<th></th>
<th>Block Premium</th>
<th>Block Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>17.2 %</td>
<td>17.1 %</td>
</tr>
<tr>
<td>ME (MJ/kg)</td>
<td>8.46 MJ/kg</td>
<td>7.37 MJ/kg</td>
</tr>
<tr>
<td>DMI</td>
<td>19.7 kg/d</td>
<td>18.0 kg/d</td>
</tr>
<tr>
<td>DMI per kg LW</td>
<td>3.8 %</td>
<td>3.6 %</td>
</tr>
<tr>
<td>Milk Potential*</td>
<td>15.5 kg/d</td>
<td>9.9 kg/d</td>
</tr>
</tbody>
</table>

* 21 and 14 kg/d in crossbred cattle

Modified from Anandan et al. (2009a)
Impact of variations in stover fodder quality on livestock productivity

- “Intuitively” small difference in fodder quality of stover do matter: additive effect of higher diet quality and higher intake

- Informed choice of cultivar can have very substantial effect on livestock productivity
Exploit existing cultivar variations and targeted genetic enhancement

**Exploit variation**
- Phenotyping new cultivars submitted for release testing for fodder traits
- Phenotyping during crop improvement for fodder traits

**Targeted enhancement**
- Conventional breeding, recurrent selection, hybridization
- Molecular breeding, QTLs, genetic selection
Stover fodder trait analysis in new sorghum cultivar release testing in India 2002 to 2008

Grain yield (kg/ha)

- Kharif: $y = 1473 + 44.2x; r = 0.17; P=0.05$
- Rabi: $y = 9208 -132x; r = -0.47; P < 0.0001$

Mean Kharif Farm Yield: 1300 kg
Mean Rabi Farm Yield: 750 kg

*Stover in vitro* organic digestibility (%)
Staygreen QTL associated sorghum stover digestibility across 2 years and 2 treatments

(Blümmel et al., 2015)
Staygreen QTL associated stover digestibility across 2 years and 2 treatments

(Blümmel et al., 2015)
Relationships between QTL associated stover digestibility and grain yields in S-35 background across years and treatments

P = 0.25; N = 6
Relationships between QTL associated stover digestibility and stover yields in S-35 background across years and treatments

(Blümmel et al., 2015)
Conclusions

• Proof of concept for multi-dimensional crop improvement provided for key cereal and legume crops

• Significant livestock nutritional cultivar variations in most crops (not wheat though) without detriment to primary traits

• Quick and inexpensive impact from exploiting variations

• Targeted genetic enhancement more longer term, more investment intensive, likely higher impact
Outlook

• Translate proof-of-concept/piloting into scaling

• Modify cultivar release criteria, add crop residue traits

• Private sector engagement for example seed bag branding with stover information (Syngenta)

• Mainstream multi-dimensional crop improvement, embedding in CRP Phase 2 crop improvement

• Hub-spoke structure with phenotyping capabilities in South Asia and East and West Africa
Thank you for your attention

better lives through livestock

ilri.org