SORGHUM SILAGE
AND ITS COMPLEMENTARITY WITH MAIZE
AS FEED DAIRY AND BEEF CATTLE

FERARD Alexis, Sorghum silage and its complementarity with maize to feed dairy and beef cattle, ARVALIS FRANCE
INSTITUTE DESCRIPTION

ARVALIS - INSTITUT DU VEGETAL: AN APPLIED AGRICULTURAL RESEARCH ORGANISATION

- Partnerships with
  - French and international basic research (INRA, IRSTEA, and Universities)
  - Development organisms
  - Economic operators (co-ops…)

- 410 collaborators
- 27 local sites in France
- 120 Research projects
Nutritive value of sorghum silage
Sorghum silage for dairy cows
Sorghum silage for young bulls fattening
Conclusion: main sorghum ID cards
### Monocut sorghum: FR Post-registration evaluation for varieties (2010-2014)

#### Chemical composition

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Silage use (n=87)</th>
<th>Dual-purpose use (n=224)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>min</td>
<td>max</td>
</tr>
<tr>
<td>CP (%)</td>
<td>6.0</td>
<td>8.2</td>
</tr>
<tr>
<td>NDF (%)</td>
<td>48.7</td>
<td>59.1</td>
</tr>
<tr>
<td>ADL (%)</td>
<td>1.8</td>
<td>3.2</td>
</tr>
<tr>
<td>OM digestibility (%)</td>
<td>56.8</td>
<td>67.0</td>
</tr>
<tr>
<td>Starch (%)</td>
<td>0.0</td>
<td>17.4</td>
</tr>
<tr>
<td>Water Soluble Carbohydrates (%)</td>
<td>12.2</td>
<td>24.0</td>
</tr>
</tbody>
</table>

#### Nutritive value

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Silage use</th>
<th>Dual-purpose use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UFL « fresh » (/kgDM)</td>
<td>0.83</td>
<td>1.01</td>
</tr>
<tr>
<td>PDIN (/kgDM)</td>
<td>39</td>
<td>53</td>
</tr>
<tr>
<td>PDIE (/kgDM)</td>
<td>67</td>
<td>75</td>
</tr>
</tbody>
</table>

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*ARVALIS-Institut du végétal, 2015*
Sorghum bicolor

- Energy value: maize equations are NOT reliable for sorghum with poor starch content
- Instead, specific equation needs to be used for all ensiled sorghum forage:

Aufrère et al., 2013:

\[
\text{DM digestibility} = 0.643 \times \text{silage DM dig. }_{\text{in vitro}} + 23.99 ; (R^2=67\% ; \text{RMSE}=2.25)
\]

\[
\text{DM digestibility} = 0.684 \times \text{silage DM dig. }_{\text{in vitro}} + 21.67 ; (R^2=65\% ; \text{RMSE}=2.61)
\]

Sudan grass and Sudan grass * sorghum bicolor

- INRA references → nutritive value varies with maturity stage → ~ tall-fescue
- Grass equations can be used
HOW TO EVALUATE THE ENERGETIC VALUE?

A very wide diversity of *sorghum bicolor*

![Diagram showing the energetic value of sorghum with different uses.](image)

- **Energy content (UFL/kgDM)**
  - 1.0
  - 0.9
  - 0.8
  - 0.7
  - 0.6

- **Starch content (g/kgDM)**
  - 0
  - 10
  - 20
  - 30

**NB:** high quality maize!

**High yielding cattle**

**Heifers, beef cattle**

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**Note:**

1 UFL/kgDM = 1700 kcal = 7.1 MJ of Net energy
High production of net energy / ha

Net energy production (UFL / ha)

DM yield (t DM/ha)

Maize silage

Sorghum « silage use »

Sorghum « dual-purpose use »

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**NUTRITIVE VALUE OF SORGHUM**

**HOW TO EVALUATE THE ENERGETIC VALUE?**

Sorghum ‘silage use’: focus on the 2 main types of sorghum without starch

*In vitro* DM digestibility (%)

```
<table>
<thead>
<tr>
<th>ADF content (g/kgDM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>40</td>
</tr>
<tr>
<td>50</td>
</tr>
</tbody>
</table>
```

**Compared to conventional sorghum**

<table>
<thead>
<tr>
<th></th>
<th>BMR</th>
<th>PS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy value</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>DM yield</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Lodging risk</td>
<td>-</td>
<td>=</td>
</tr>
<tr>
<td>Energy/ha</td>
<td>= or +</td>
<td>= or +</td>
</tr>
</tbody>
</table>


FERARD Alexis, Sorghum silage and its complementarity with maize to feed dairy and beef cattle

BUCHAREST 3-4 NOVEMBER 2016
SORGHUM SILAGE FOR DAIRY COWS
COMPLEMENTARITY SORGHUM – MAIZE SILAGE

Replacing 50% of maize silage by sorghum silage ‘dual-purpose use’ (0.81 UFL, 30% of DM, 13% of starch)

Comparison in % to control = maize silage only

Sorghum silage permits to reduce diet starch content to boost milk fat

-15% -10% -5% 0% 5% 10%

* DM intake
* Milk fat
* 4% fat corrected milk
* Feed efficiency: FCM/DMI

Brunschwig P. et Lamy J.M. 2008
COMPLEMENTARITY SORGHUM – MAIZE SILAGE

Replacing 50% of maize silage by BMR sorghum silage ‘silage use’ (0.92 UFL, 26% of DM, 6% of starch)

Comparison in % to control = maize silage only

-6%  -4%  -2%  0%  2%  4%  6%  8%

Milk
Milk fat
DM intake

Feed efficiency: FCM/DMI

Sorghum boosts milk fat
BMR Sorghum lower diet starch content ➔ Improves diet digestibility and feed efficiency

ARVALIS synthesis of 5 trials in experimental farms.
### SORGHUM SILAGE FOR DAIRY COWS

#### SORGHUM SILAGE AS SOLE FORAGE

<table>
<thead>
<tr>
<th>Comparison in % to control</th>
<th>DM Intake</th>
<th>Milk</th>
<th>4% Fat corrected milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>sorghum &quot;silage use&quot; &gt;20% of starch</td>
<td>« dual-purpose use&quot;</td>
<td>sorghum &quot;silage use&quot; &lt;5% of starch</td>
<td></td>
</tr>
</tbody>
</table>

Maximize milk production

↓ milk/cow

high DM yield that maintains milk/ha

Acidosis-secured diet

Good milk production

ARVALIS synthesis of trials in experimental farms.

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SORGHUM 'SILAGE USE':
FOCUS ON THE 'GRAIN' TYPE

- Chemical composition close to maize
- Ingestibility higher than maize
- Maintain milk production
- Needs to be harvested at milk-dough stage
  - 30-33% of DM (with 25% of starch)
  - Short length of cut and processing rolls tightened to crack the kernels

/!/ Caution:
harvest at DM>35% → decrease by 10% milk and feed efficiency
COMPLEMENTARITY SORGHUM – MAIZE SILAGE

Introducing 50% of BMR sorghum in a maize-based diet

Feed cost variation/1000kg of milk

<table>
<thead>
<tr>
<th>DM yield(^1) of BMR maize (tDM/ha)</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM yield(^1) of BMR sorghum (tDM/ha)</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>0</td>
<td>-4</td>
<td>-6</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>5</td>
<td>1</td>
<td>-3</td>
</tr>
<tr>
<td>12</td>
<td>14</td>
<td>8</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>16</td>
<td>12</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>

Rouillé et al., 2010

Where BMR sorghum can grow normally

→ 0 to 16€/1000L i.e. 0 to 15% of reduction of feed costs for milk production

\(^1\) Non-irrigated crop
Introducing 50% of grain or dual-purpose sorghum in a maize-based diet

- \( \downarrow \) inputs/ha of forage crop (seeds, irrigation, fertilisation)
- \( \uparrow \) Milk Fat
- \( \downarrow \downarrow \) Milk yield
- Stabilise the DM yield/ha of forage especially in case of continental conditions
- Reduce feed efficiency by 10%

\[ \Rightarrow \text{ Usually, feed cost/1000 kg of milk will be reduced if } \]
\[ DM \text{ yield }_{sorghum} > 1.1 \times DM \text{ yield }_{maize} \]
SORGHUM SILAGE FOR BEEF CATTLE
→ INDOOR YOUNG BULLS FINISHING
SORGHUM SILAGE INGESTIBILITY: THE KEY POINT

Fattening trial with Limousine young bulls until 420-430 kg carc. weight

**Diet:** [100% BMR sorghum silage vs 100% Maize silage] + concentrate

BMR sorghum has high ingestibility if DM>25%

If ingestibility is high → ADG similar to maize control

Guillaume et al., 2014
SORGHUM SILAGE INGESTIBILITY: THE KEY POINT

Fattening trial with Charolais young bulls until 435 kg carc. weight

<table>
<thead>
<tr>
<th>3 Diets compared:</th>
<th>Control 100% maize silage</th>
<th>50% maize silage + 50% grain sorghum ensiled</th>
<th>Mixed silage (maize + BMR sorghum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM intake (kgDM/d)</td>
<td>10,0</td>
<td>+ 0,30</td>
<td>- 0,15</td>
</tr>
<tr>
<td>ADG (g/d)</td>
<td>1610</td>
<td>+ 10</td>
<td>+ 30</td>
</tr>
<tr>
<td>Fattening duration (d)</td>
<td>220</td>
<td>- 3</td>
<td>- 3</td>
</tr>
<tr>
<td>DM intake / kg of carcass gain</td>
<td>10,3</td>
<td>=</td>
<td>- 0,6</td>
</tr>
</tbody>
</table>

BMR sorghum: ~ very good wilted grass ⇒ very positive on growing perf.

Grain sorghum: very high ingestibility and growing perf. = maize

ARVALIS-Institut du végétal, 2014
Introducing 50% of BMR sorghum in a maize-based diet

Feed cost variation / young bull carcass produced

<table>
<thead>
<tr>
<th>€ / YB</th>
<th>DM yield(^1) of maize (tDM/ha)</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM yield(^1) of BMR sorghum (tDM/ha)</td>
<td>6</td>
<td>-4</td>
<td>-13</td>
<td>-19</td>
<td>-24</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>11</td>
<td>-1</td>
<td>-9</td>
<td>-15</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>27</td>
<td>11</td>
<td>1</td>
<td>-6</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>42</td>
<td>23</td>
<td>11</td>
<td>3</td>
</tr>
</tbody>
</table>

Where BMR sorghum can grow normally
→ 0 to 15% of reduction of feed costs per YB compared to maize

\(^1\) Non-irrigated crop

ARVALIS-Institut du végétal, 2014
SORGHUM SILAGE FOR BEEF CATTLE

SORGHUM SILAGE ECONOMIC INTEREST

Other sorghum in a maize-based diet – comparison to 100% maize

<table>
<thead>
<tr>
<th></th>
<th>ADG</th>
<th>Feed costs with DM yield sorghum=maize</th>
<th>Feed costs with DM yield sorghum = 1.2 * maize</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain sorghum</td>
<td>=</td>
<td>~ 0%</td>
<td>-3 %</td>
</tr>
<tr>
<td>UFV&gt;0.85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPS sorghum</td>
<td>-1 to -3 %</td>
<td>~ 0%</td>
<td>-1 to -3 %</td>
</tr>
<tr>
<td>UFV&gt;0.80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other sorghum</td>
<td>-5 to -10%</td>
<td>+3 to +10%</td>
<td>-1 to +5 %</td>
</tr>
<tr>
<td>UFV&lt;0.80</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

With ‘silage use’ sorghum

→ mostly positive on feed costs compared to maize control diets
DIFFERENT SORGHUM FOR DIFFERENT USES: A SUMMARY

GRAZED SORGHUM

“SILAGE USE”: BMR SORGHUM

“SILAGE USE”: PPS SORGHUM

“SILAGE USE”: GRAIN SORGHUM

“DUAL-PURPOSE USE”
GRAZED SORGHUM

- Sudan grass or hybrids Sudan grass * sorghum bicolor
- Avoid toxicity by grazing not before 40 cm (Sudan grass), 50-60 cm (hybrids)
  → Usually 5-6 weeks after seeding
- BMR: +12% ADG (Trostle, 2004)
“SILAGE USE”: BMR SORGHUM

Same energy value as maize
Target: mini 25%DM at harvest

- Improve whole diet digestibility
- Slight decrease of DMI
- Maintain milk production /ADG
- Positive effect on feed efficiency
- Profitable even if DM yield sorghum is 5% less than maize
“SILAGE USE”: PPS SORGHUM

Energy value is ~90% of maize

Target: at least 25%DM at harvest

High DM yield/ha

- Improve whole diet digestibility
- Slight decrease of DMI, ADG and milk production if sole forage
- Recommended associated with maize silage
- Profitable if DM yield sorghum ≥ maize
“SILAGE USE”: GRAIN SORGHUM

Energy value is ~95% of maize

Target: 30%DM at harvest

- Increase by 5 to 10% the DM intake
- Maintain ADG and milk production if sole forage or associated
- Double use crop – no lodging
- Profitable if DM yield sorghum ≥ 1.15 * maize
“DUAL-PURPOSE USE”

Energy value is 80-90% of maize
Target: at least 25%DM at harvest

- High DM yield of the crop
- Decrease by 5 to 10% DM intake, ADG and milk production
- Recommended as 2-4 kgDM/day/cow, heifers, beef cattle and young bulls with ADG potential ≤ 1500g/d
- Profitable if costs of sorghum ≥ 0.8 * maize
CONCLUSION

DIFFERENT SORGHUM FOR DIFFERENT USES

High production of net energy/ha

DM intake:
↘ (no starch)
Or ↗ (grain)

Milk fat ↗

Milk production and ADG remain high