Silage quality of maize-climbing bean intercropping

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Abstract

Silage maize is a major forage source in the livestock production of many countries. It has relatively consistent nutritive value and high energy density, but relatively low crude protein content. The intercropping of maize with climbing bean (Phaseolus vulgaris L.) may serve as a way to increase crude protein and improve the overall nutritive value of silage. A field experiment was carried out in 2008 in order to determine the silage quality of maize (cv. Nexxos), monocropped or intercropped with climbing bean (cv. Jabeljski visoki). Maize sown in two densities (6 and 9 plants m⁻²) was intercropped with climbing bean in maize-bean ratios: 1:1, 1:2 and 2:1. Silages were analysed for dry matter (DM), crude protein (CP), fat (CF), fibre (CFb) and ash (CA). All intercrop silages had higher crude protein values (71.0-79.3 g kg⁻¹) and crude fat contents (45.2-50.1 g kg⁻¹) than pure maize (65.6 and 19.6 g kg⁻¹, respectively). The calculated energy densities (GE) of all intercrop silages were significantly higher (18.7-19.1 MJ kg⁻¹) than that of pure maize (18.2 MJ kg⁻¹).

Key words: intercropping, maize, climbing bean, silage quality

Introduction

Energy and protein sources are of prime importance for ruminants as they stimulate microorganisms in the rumen and enhance the productive functions of the animals. Maize silage plays an important role as a winter feed in the livestock production of many countries and it comprises approximately 17.3% of arable land in Slovenia (SURS, 2005). The main advantages of silage maize are high yield obtained in a single harvest, simple ensilaging process and high energy value of maize as a feed. It has relatively consistent nutritive value and high energy density, but relatively low crude protein content, ranged between 53 and 105 g kg⁻¹ dry matter (Verbič, 2008).

Intercropping, the simultaneous cultivation of more than one species or cultivar on the same area of land, is being advocated as a new and improved approach to farming (INTERCROP, 2006). Proper spatial arrangements, planting rates and the maturity dates of components in maize-grain legume intercropping enhance biodiversity and have many advantages over pure maize cropping. The advantages are related to complementary use of environmental resources, increased and/or more stable yield which provides greater financial stability, better nutrient recycling and improved use of renewable nitrogen source by fixation, better weed, pest and diseases control, and may also serve as an alternative to increase the crude protein of silage (Rao and Morgado, 1984; Vandermeer, 1989; Anil and Phipps, 1998; Anil et al., 2000).

The present study was conducted to evaluate the silage quality of maize-climbing bean intercropping treatments, differing in planting and spatial arrangements, as an alternative to pure maize cropping.

Materials and methods

Intercropping systems with different densities and spatial patterns of maize-climbing bean have been studied at the Faculty of Agriculture and Life Sciences at the University of Maribor over a four-year period (Bavec et al., 2005; Bavec et al., unpublished data). In addition to investigating the growth of intercropped crops and their productivity performance in previous years, in 2008, the silage quality was evaluated. The fresh material
used in this study was produced at the University Agriculture Centre Pohorski Dvor, Maribor, north-east Slovenia (46°39'N, 15°41'E, 282 m.a.s.l.), with 9.8 °C and 1047 mm as the long-term medium. The soil texture was sandy-loam (Dystric Cambisols on slate metamorphic rocks) with pH 6.0, 2.6% of organic carbon, 29.5 mg P₂O₅/100 g⁻¹, 12.7 g K₂O 100 g⁻¹ (ammonium lactate) and 159 kg ha⁻¹ of mineral nitrogen up to depth 0.9 m. The measurements were taken before maize sowing. In late April dent maize (*Zea mays* var. *indentata*) cv. Nexxos was sown in two densities (6 and 9 plants m⁻²), as a pure crop and in intercropping with indeterminate-type climbing bean cv. Jabelski visoki. Climbing bean was sown close to maize in different maize to climbing bean planting ratios (1:1, 1:2 and 2:1) at maize growth stage 15 BBCH. The field experiment was set up in systematic - Mead’s adaptation of Bleasdale’s row design (Petersen, 1994) in one replication. Weeding was performed manually. The harvest was gathered on September 11, at the maize maturity stage of 1/2 to 3/4 milk line. Harvested intercrops were separated into maize and climbing bean, and components weight proportions were determined.

Maize and intercrops were chopped with a transportable chopper to a theoretical particle size of 0.5 cm. Obtained material was thoroughly mixed and filled in a 10-L plastic barrel.

Mini-silos were tightly sealed and kept in a storehouse (~20 °C) without light for 120 days. Ensilage was performed without additives in four replications. At the time of silo opening the content was homogenized and samples of 500 g were taken for further analyses.

The ensiled samples were analysed at the Institute of Agriculture and Forestry Murska Sobota (Slovenia). Dried samples (dried at 60 °C for 48 h in a forced-air oven) were ground by hammer mill, sieved through a 1 mm screen and stored in polyethylene bags until the analysis. According to the procedure dry matter (DM), crude protein (CP; Kjehldahl N x 6.25), crude fibre (CFb), crude fat (CF), ash (CA) and nitrogen free extract (NFE) were determined according to the standard procedures. All the parameters were expressed on a DM basis. The gross energy (GE) of the silages was calculated according to the proximate analysis using an official German equation (Gesellschaft für Ernährung, 1999):

\[
GE (MJ kg^{-1}) = 0.0239 \times g \text{ CP} + 0.0398 \times g \text{ CF} + 0.0201 \times g \text{ CFb} + 0.0175 \times g \text{ NFI}
\]

Data were evaluated by analysis of variance using the Statgraphics Centurion XV statistical program (Statgraphics®, 2005) with the significance level set at P ≤ 0.05. Comparison of means was done by Duncan test (\(\alpha=0.05\)).

### Results and discussion

Since the present experiment was established in 2008 in addition to a trial run from the previous years, and exclusively for the purpose of silage quality evaluation, the results presented in Table 1 serve purely for illustrating the components contribution to total yield of silage mixtures.

<table>
<thead>
<tr>
<th>Mixture (M:B; plants m⁻²)</th>
<th>Yield total (kg 10 m⁻²)</th>
<th>Component (kg, plants 10 m⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M (%)</td>
</tr>
<tr>
<td>M6B3</td>
<td>57.91</td>
<td>54.96 (94.9)</td>
</tr>
<tr>
<td>M6B6</td>
<td>36.21</td>
<td>34.91 (96.4)</td>
</tr>
<tr>
<td>M6B12</td>
<td>30.16</td>
<td>27.46 (96.9)</td>
</tr>
<tr>
<td>M9B4.5</td>
<td>64.26</td>
<td>63.01 (98.1)</td>
</tr>
<tr>
<td>M9B9</td>
<td>60.31</td>
<td>59.16 (98.1)</td>
</tr>
<tr>
<td>M9B18</td>
<td>76.59</td>
<td>74.60 (97.4)</td>
</tr>
</tbody>
</table>

Table 2 shows the proximate chemical composition and gross energy of silage obtained from pure cropping maize (pure maize) and maize-climbing bean mixtures (M:B). While average CFb content did not differ, other silage constituents were significantly different among treatments. Average DM concentrations of analysed silages were between 330 and 395 g kg⁻¹, and therefore in the range of recommended values (300-400 g kg⁻¹) (Verbič, 2008). However, the pure maize silage had a significantly lower average DM content than silages obtained from mixtures where maize was sown at the density of 6 plants m⁻². It is known that protein, fat and mineral contents of legumes are higher than that of cereals (Souci et al., 1994). With exception of treatment M6B12, the recorded CP contents of all other maize-climbing bean silages were significantly
higher than the concentration obtained by pure maize (65.6 g kg⁻¹). Similarly, the increase of silage CP content in maize-climbing bean intercropped silage mixtures is also reported in literature (Anil et al., 2000; Armstrong et al., 2005; Bildirici et al., 2009). The content of CF in pure maize was significantly lower than in silages made from mixtures (p<0.01). The average CA content of all intercropped mixtures established with higher maize density (9 plants m⁻²) was higher in comparison to the silage derived from pure maize. As expected, the NFE of pure maize silage was higher than those from mixtures. The calculated GE of all intercrop silages was significantly higher (18.7-19.1 MJ kg⁻¹), than that of pure maize (18.2 MJ kg⁻¹).

### Table 2. Chemical composition of maize and different maize-climbing bean intercropped silage mixtures

<table>
<thead>
<tr>
<th>Mixture (M:B)</th>
<th>DM** (g kg⁻¹)</th>
<th>CP** (g kg⁻¹)</th>
<th>CF** (g kg⁻¹ DM)</th>
<th>CFb** (g kg⁻¹)</th>
<th>CA** (g kg⁻¹)</th>
<th>NFE* (MJ kg⁻¹)</th>
<th>GE** (MJ kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mpure</td>
<td>330d</td>
<td>65.6c</td>
<td>19.6b</td>
<td>176.1</td>
<td>36.7c</td>
<td>702.0a</td>
<td>18.2d</td>
</tr>
<tr>
<td>M6B3</td>
<td>395a</td>
<td>79.2a</td>
<td>46.9a</td>
<td>231.9</td>
<td>34.4c</td>
<td>607.6b</td>
<td>19.1a</td>
</tr>
<tr>
<td>M6B6</td>
<td>386ab</td>
<td>74.1ab</td>
<td>49.0a</td>
<td>194.2</td>
<td>37.5bc</td>
<td>645.2b</td>
<td>18.9ab</td>
</tr>
<tr>
<td>M6B12</td>
<td>374abc</td>
<td>71.0bc</td>
<td>48.7a</td>
<td>222.1</td>
<td>44.4a</td>
<td>613.7b</td>
<td>18.8bc</td>
</tr>
<tr>
<td>M9B4.5</td>
<td>363bcd</td>
<td>79.3abc</td>
<td>50.1a</td>
<td>209.7</td>
<td>42.4a</td>
<td>618.5b</td>
<td>18.9ab</td>
</tr>
<tr>
<td>M9B9</td>
<td>352bcd</td>
<td>72.2b</td>
<td>47.4a</td>
<td>208.3</td>
<td>41.7ab</td>
<td>630.4b</td>
<td>18.8bc</td>
</tr>
<tr>
<td>M9B18</td>
<td>362bcd</td>
<td>76.4ab</td>
<td>45.2a</td>
<td>201.2</td>
<td>44.7a</td>
<td>632.4b</td>
<td>18.7c</td>
</tr>
</tbody>
</table>

**significant at the 0.01 probability levels; ns - non significant

*mean values followed by different letters within a column are significantly different (Duncan, α=0.05)

### Conclusions

The research work conducted in previous years demonstrates the feasibility of intercropping maize with climbing bean, and the present study confirms the advantage of such mixtures in the view of silage quality. Maize-climbing bean mixtures provided silage with improved crude protein, crude fat and subsequently gross energy value.

### Acknowledgements

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### References


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