Intercropping maize (Zea mays L.) and cow pea (Vigna unguiculata L.) as a whole–crop forage: Effects of planting ratio and harvest time on forage yield and quality

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Abstract

Sole crops and intercrops of maize (Zea mays L.) and cow pea (Vigna unguiculata L.) at eight planting ratios of maize:cowpea (100:100, 50:100, 100:50, 25:75, 75:25, 50:50, 0:100 and 100:0) and two harvest times (milky stage and doughty stage) were evaluated for quality characteristics of dry matter digestibility (DMD), crude protein (CP), neutral–detergent fiber (NDF), acid–detergent fiber (ADF) and water–soluble carbohydrate (WSC) concentrations and ash content. This experiment was carried during over two years (2007 and 2008) on Research Center, University of Zabol, Iran. Results indicated that optimum forage quality from milky stage was obtained. Maize and cowpea intercrops were higher in total forage dry matter digestibility (DMD) than maize or cowpea grown as sole crops. Cowpea intercropped with maize led to increased forage quality (CP and DMD concentration) compared with sole-maize, and higher WSC concentrations compared with sole cowpea. The highest crude protein content was obtained by harvest time in milky stage (15.2%). It is suggested that maize–cowpea intercrops may have considerable potential as a high quality.

Key words: Maize-cowpea, intercrop, harvest time, planting ratio, forage.

Introduction

Intercropping of legumes and cereals is an old practice in tropical agriculture that dates back to ancient civilization. The main objective of intercropping has been to maximize use of resources such as space, light and nutrients 26, as well as to improve forage quality and quantity 1, 18, 29, 30. The current trend in global agriculture is to search for highly productive, sustainable and environmentally friendly cropping systems 11. When two crops are planted together, inter specific competition or facilitation between plants may occur 39. Intercropping is being advocated as a new and improved approach to farming. However, it has been avoided because of the complications of planting and harvesting. Intercropping involves competition for light, water and nutrients. However, intercropping usually benefits from increased light interception, root contact with more soil, increased microbial activity and can act as a deterrent to pests and weeds of the other crop. There is also evidence that suggests intercropping may benefit a non-legume which needs nitrogen if the other crop is a legume, since legumes will fix nitrogen in the soil 4. Production of good quality fodder is of a great importance for the economical ruminant production. Both quality and quantity of fodder are influenced due to plant species 18, 21, stage of growth 18, 22 and agronomic practices 17, 31. The growing of fodder crops in mixture with legumes enhanced fodder palatability and digestibility 8. Intercropping of cereals and legumes produce higher grain yields than either sole crop 12, 30. In such intercropping, the yield increases were due to improved resources of intercrops compared to sole crops 16. Mixing of legumes in cereals is a better choice to increase the quality of forage. It has been reported that dry matter yields of maize sown as sole crops were greater than soybean intercropping. However, intercropping gave higher crude protein yields than maize as sole crop 22. The highest dry matter yield was obtained when maize and soybean were intercropped in a ratio of 1:1. Mixing of legumes in cereals is a better choice to increase the quality of cereal fodders 2. Lower yield of green fodder was harvested by growing cowpea alone as compared to pure stand of maize 28.

Intercropping offers to farmers the opportunity to engage nature’s principle of diversity at their farms. Spatial arrangements of plants, planting rates and maturity dates must be considered when planning intercrops 19. Therefore, it is necessary value to carry out an experiment on green fodder yield and fodder quality of maize in relation to different planting ratio and harvest time. For obtaining a good fodder of improved quality, an accurate balance of legumes and non-legumes in a mixture is very essential. The objectives of the research reported here were: (i) to assess the potential of maize-cowpea intercrops to enhance forage yield and quality when compared with maize sole crops and (ii) to determine the effect to planting ratios and harvest time on forage yield and quality.

Materials and Methods

Site: The field experiment was carried out on the University of Zabol farm, Iran (61°41´E, 30°54´N, altitude 483 m above sea level). Average 30 years rainfall was 49 mm. The experiment was carried out during 2007 and 2008 growing season (Table 1) on a sandy-loam soil (Table 2).

All phosphorus (150 kg/ha) and potassium (100 kg/ha) and half...
of nitrogen (50 kg/ha) were applied at sowing while rest of nitrogen was applied at stem elongation stage. All other cultural practices including irrigation, thinning and weeding were kept normal and uniform for all the treatments.

**Experimental design and treatments:** The treatments were compared in a factorial design with eight levels of planting ratios 100:100 (M:C), 50:100 (m:C), 100:50 (M:c), 50:50 (m:c), 75:25 (M’:c’), 25:75 (m’:C’), 0:100 (C) and 100:0 (M) and two levels of maturity stages (milky stage and doughy stage) in four replications. The treatments used for this experiment are summarized in Table 3. The treatment comprising the individual plot size was 7 m × 4 m.

**Statistical analysis:** The data on growth, yield and quality parameters were analyzed by Fisher’s analysis of variance technique and Duncan test at 0.05 probability level to compare the treatment means. Data analyses were conducted using SAS 33 as a factorial experiment 8 × 2 with four replicates.

**Results**

**Experiment 1 (Spring 2007):** Dry matter digestibility (DMD) was greatly (p<0.01) affected by harvest time. The mean DMD over milky stage (H1) was 61.5%. The intercrop Mc (100% maize + 50% cowpea) produced the highest of DMD (62.5%) and the intercrop m’C’ (maize 25% + cowpea 75%) produced the lowest DMD (Table 4). Crude protein (CP) was greatly (p<0.01) affected by harvest time and planting ratios. The mean CP concentration of sole cowpea (19.6%) was considerably greater than that of sole maize (12.1%). The CP concentration averaged over all intercrop treatments was also greater than that of sole maize (Table 4).

Acid detergent fiber (ADF) concentration of forage declined (p<0.01) between H1 and H2. ADF concentration was significantly (p<0.01) greater than that for sole cowpea being greater than that for sole maize.

Neutral detergent fiber (NDF) concentration showed a significant (p<0.01) effect by harvest time. NDF concentration decreased with harvest time, the highest NDF was at H1 harvest time (Table 4). NDF concentration of the intercrops and sole crops were not significantly affected.

Water-soluble carbohydrate (WSC) concentration at H2 was greater than at H1. WSC concentration of sole maize was significantly (p<0.01) greater than that for sole bean and intercrops (Table 4). WSC concentration for all intercrops was greater than that for sole cowpea.

The mean ash concentration decreased (p<0.01) with harvest time. Ash concentration of intercrops and sole cowpea was higher (p<0.01) than that of sole maize, sole cowpea had higher ash concentration (10.1%) compared to other intercrops and sole maize (Table 4).

Green fodder yield (GFY) was greatly (p<0.01) affected by harvest time and planting ratios. The mean GF yield at H2 (46.2 t/ha) was greater than at H1 (21.6 t/ha). The GF yield was also affected by planting ratio, and the highest DF yield (46.7 t/ha) was recorded for MC ratio (Table 4).

Dry fodder yield (DFY) was greatly (p<0.01) affected by harvest time and planting ratio. The mean DF yield at H2 (9.3 t/ha) was greater than at H1 (7.6 t/ha). The DF yield was also affected by planting ratio, and the highest DF yield (11.4 t/ha) was recorded for MC ratio (Table 4).

**Experiment 2 (Spring 2008):** Dry matter digestibility was significantly (p<0.01) affected by harvest time. The highest DMD was achieved at H1 (70.6%) that was greater than at H2. DMD was

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**Table 1. Monthly average temperature, relative humidity and wind speed recorded at Zabol, Iran, during the 2007 and 2008 growing seasons.**

<table>
<thead>
<tr>
<th>Month</th>
<th>Temperature (°C)</th>
<th>Precipitation (mm)</th>
<th>Wind speed (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>14.1</td>
<td>10.8</td>
<td>14.5</td>
</tr>
<tr>
<td>April</td>
<td>24.1</td>
<td>24.2</td>
<td>20.5</td>
</tr>
<tr>
<td>May</td>
<td>28.1</td>
<td>34.3</td>
<td>27.1</td>
</tr>
<tr>
<td>June</td>
<td>31.9</td>
<td>34.7</td>
<td>31.8</td>
</tr>
<tr>
<td>July</td>
<td>34.5</td>
<td>37.2</td>
<td>34.5</td>
</tr>
</tbody>
</table>

**Table 2. Soil characteristics of the experiment area during the 2007 and 2008 growing seasons.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Depth (cm)</th>
<th>pH</th>
<th>EC (mmhos/cm)</th>
<th>N(%)</th>
<th>P (ppm)</th>
<th>K (ppm)</th>
<th>Sand (%)</th>
<th>Silt (%)</th>
<th>Clay (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>0-20</td>
<td>8.0</td>
<td>7.8</td>
<td>0.053</td>
<td>7.8</td>
<td>190</td>
<td>63</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>2008</td>
<td>0-20</td>
<td>7.9</td>
<td>5.4</td>
<td>0.022</td>
<td>3.4</td>
<td>210</td>
<td>52</td>
<td>28</td>
<td>20</td>
</tr>
</tbody>
</table>

**Table 3. The description of experiment treatments.**

<table>
<thead>
<tr>
<th>Factor A</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>Sole maize (100% maize + 0% cowpea)</td>
</tr>
<tr>
<td>C</td>
<td>Sole cow pea (100% cowpea + 0% maize)</td>
</tr>
<tr>
<td>MC</td>
<td>Intercrop of maize 100% + cowpea 100%</td>
</tr>
<tr>
<td>Mc</td>
<td>Intercrop of maize 50% + cowpea 100%</td>
</tr>
<tr>
<td>mC</td>
<td>Intercrop of maize 50% + cowpea 50%</td>
</tr>
<tr>
<td>M’c’</td>
<td>Intercrop of maize 75% + cowpea 25%</td>
</tr>
<tr>
<td>m’C’</td>
<td>Intercrop of maize 25% + cowpea 75%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor B</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>Harvest at milky stage</td>
</tr>
<tr>
<td>H2</td>
<td>Harvest at doughy stage</td>
</tr>
</tbody>
</table>

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affected (p<0.01) by planting ratio. The intercrops Mc (100% maize + 50% cowpea) produced the highest DMD (70.9%), and the intercrop m'C (maize 25% + cowpea 75%) produced the lowest DMD (Table 4). The DMD of the intercrop was between the sole maize and higher than that for sole cowpea (Table 4).

Crude protein (CP) concentration of forage was affected by harvest time. CP was greatly (p<0.01) affected by harvest time and planting ratio. CP concentration at H1 (14.4%) was greater than at H2 (Table 4). The mean CP concentration of sole cowpea (15.5%) was considerably greater than that of sole maize (12.2%). The CP concentration averaged over all intercrop treatments was also greater than that of sole maize (Table 4).

Ash concentration was significantly (p<0.01) affected by both harvest time and planting ratio. Ash concentration of the intercrop and sole maize was less than that of sole cowpea. Ash concentration at H2 was greater than at H1 (Table 4).

Green (GFY) was greatly (p<0.01) affected by harvest time and planting ratio. The mean GF yield at H1 (37.3 t/ha) was greater than that of H2 (17.6 t/ha). The GF yield was also affected by planting ratio, and the highest GF yield (38.1 t/ha) was recorded of MC ratio (Table 4).

Dry fodder yield (DFY) was greatly (p<0.01) affected by harvest time and planting ratios. The mean DF yield at H1 (7.0 t/ha) was greater than that at H2 (5.1 t/ha). The DF yield was also affected by planting ratio, and the highest DF yield (9.3 t/ha) was recorded of M (sole maize) ratio (Table 4).

**Discussion**

The results showed that an increased proportion of bean in intercrops increased the crude protein contents. These results are supported by some earlier researches 28. Effect of legume intercrops on protein concentration of main crop has also been reported 5, 30. The mean intercrop CP concentration, across H1 and H2, were 15.2 and 12.3% for Experiment 1 and 14.4 and 12.4% for Experiment 2. These were greater than in maize but less than in cowpea. Similar results have been obtained for maize 20. Maximum crude protein (15.2%) was obtained in milky stage, and minimum crude protein (12.3%) was obtained in doughy stage. A decrease of CP content with maturity was also reported by other workers 18, 38. Crude protein has previously been shown to decline with increasing maturity 34. Armstrong et al. 2 reported that

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**Table 4.** Means of green fodder yield and quality parameters as influenced by different planting ratios and harvest time of intercropping maize and bean based on Duncan Test.

<table>
<thead>
<tr>
<th>Maize: cowpea planting ratio</th>
<th>Green fodder yield (t/ha)</th>
<th>Dry fodder yield (t/ha)</th>
<th>DMD (%)</th>
<th>NDF (%)</th>
<th>ADF (%)</th>
<th>WSC (%)</th>
<th>Ash (%)</th>
<th>CP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100:100</td>
<td>46.7 a</td>
<td>11.4 a</td>
<td>60.26ab</td>
<td>55.55 a</td>
<td>27.11bc</td>
<td>18.15bc</td>
<td>7.25bc</td>
<td>13.22bc</td>
</tr>
<tr>
<td>100:50</td>
<td>40.0 bc</td>
<td>10.7 ab</td>
<td>62.52 a</td>
<td>54.25 a</td>
<td>25.89c</td>
<td>20.04ab</td>
<td>7.29b</td>
<td>13.04bc</td>
</tr>
<tr>
<td>50:100</td>
<td>23.6 d</td>
<td>7.6 d</td>
<td>57.84ab</td>
<td>57.95a</td>
<td>29.88ab</td>
<td>18.16bc</td>
<td>7.35b</td>
<td>13.62b</td>
</tr>
<tr>
<td>50:50</td>
<td>26.4 d</td>
<td>6.3 e</td>
<td>60.66ab</td>
<td>55.34a</td>
<td>26.33bc</td>
<td>20.58a</td>
<td>6.82c</td>
<td>12.33c</td>
</tr>
<tr>
<td>25:75</td>
<td>16.0e</td>
<td>3.6 f</td>
<td>56.30b</td>
<td>54.44a</td>
<td>31.04b</td>
<td>18.25bc</td>
<td>7.44b</td>
<td>13.94b</td>
</tr>
<tr>
<td>75:25</td>
<td>38.7 c</td>
<td>9.5 c</td>
<td>60.50ab</td>
<td>55.39a</td>
<td>26.87bc</td>
<td>20.46a</td>
<td>7.04b</td>
<td>12.22c</td>
</tr>
<tr>
<td>100:0</td>
<td>41.9 b</td>
<td>10.8 ab</td>
<td>61.17ab</td>
<td>55.86a</td>
<td>26.53bc</td>
<td>20.69a</td>
<td>7.00bc</td>
<td>12.11c</td>
</tr>
<tr>
<td>0:100</td>
<td>37.9 c</td>
<td>10.3 bc</td>
<td>57.46b</td>
<td>54.46a</td>
<td>29.35ab</td>
<td>16.65c</td>
<td>10.10a</td>
<td>19.65a</td>
</tr>
</tbody>
</table>

**Harvest time**

<table>
<thead>
<tr>
<th>S.E.</th>
<th>3008</th>
<th>8.85</th>
<th>9.76</th>
<th>7.31</th>
<th>7.95</th>
<th>12.3</th>
<th>9.2</th>
<th>5.38</th>
<th>8.33</th>
</tr>
</thead>
</table>

| 2007 | 2008 |

**Any two means not sharing a common letter differ significantly from each other at 5% probability.**
intercropping climbing beans with corn increased neutral detergent fiber concentration and decreased digestibility compared to monoculture corn. Dawo et al. 13, reported that CP concentration increased 22% in the mixture when corn proportion in the mixture decreased by 50%. Our results are in agreement with studies where legumes also increased CP concentration when in mixture with corn 1-13.

Quality measured indicated an advantage for cowpea, which exhibited lower NDF and higher CP content than maize. These results are in accordance with Boxton 6 and Caballero 7, who stated that NDF and CP contents of legumes were usually less and greater, respectively, than those for cereals. For both Experiment 1 and 2, reduction in NDF and ADF concentration of forage from H1 compared with H2, can be attributed to increasing of grain to whole biomass ratio. Similar results have been reported by others working with sorghum-soybean 14 and maize 15. Harvest time also affected significantly ADF; maximum ADF was recorded by milk stage. A decline in fiber concentration with increasing maturity can be attributed to the dilution effect created by the increasing content of grain as corn matures 10.

A reduction in WSC concentration with harvest time is in accordance with results of Kristensen 24 and Leaver and Hill 25. For both experiments, WSC concentration increased in intercrops compared with that in sole cowpea, and agrees with Kristensen 24 for barley–bean compared with sole bean. The highest WSC was recorded for sole maize and sole crop of cowpea produced the lowest WSC and dry matter digestibility. These results agree with the findings of Kristensen 24 and Evans et al. 15. In maize WSC content increased as crop matured from milk to doughy stage. An increase in WSC with increasing maturity can be attributed to the dilution effect created by the increasing content ratio of grain to fodder as corn matures 36. Johnson and McClure 37 reported increased soluble carbohydrate in stalls from tasseling to the milk stage and a decline thereafter. Plots were established at the University of Wisconsin, with advancing maturity. Contreras-Govea et al. 8 reported that intercropping clover (Trifolium ambiguum M. Bieb.) with winter wheat (Triticum aestivum L.) for silage increased water-soluble carbohydrates compared with clover and CP concentration compared with monoculture winter wheat. Decrease in ash concentration with maturity could result from dilution of minerals as crop mature and agree with Esmail et al. 14 and Ghanbari-Bonjar et al.18. Esmail et al. 14 reported that ash content of grain sorghum–soybean at early to mid growth stages (milky stage) was significantly greater than for sole sorghum. Also in our study the sole cowpea produced the lowest green fodder as well as dry matter. Similar results have been reported earlier 3. Fresh biomass production in mixtures was higher than in sole crop cowpea due to the contributions by legumes in the mixtures. Some researchers reported that legume contribution to corn in mixtures was significant and increased the total biomass yields of mixtures 15.

Conclusions
This study clearly brought out the beneficial effects of maize-cowpea intercropping for forage yield and quality. Intercropping is more productive than sole cropping. Maize-cowpea intercropping increased green fodder yield and forage quality of maize. Therefore, this initial investigation shows that results of maize/climbing cowpea mixture were advantageous compared to both sole crops of maize and cowpea.

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References
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