Effect of Crop Maturity Stages on Yield, Silage Chemical Composition and In vivo Digestibilities of the Maize, Sorghum and Sorghum-Sudangrass Hybrids Grown in Semi-Arid Conditions

Ismail Gul, Ramazan Demirel, Numan Kilicalp, Mehdi Sumerli and Hasan Kilic
Department of Field Crops, Department of Animal Science, Faculty of Agriculture, University of Dicle, 21280 Diyarbakir, Turkey
Cukurova Agricultural Research Institute, 01120, Adana, Turkey
Southeastern Anatolian Agricultural Research Institute, Diyarbakir, Turkey

Abstract: The effect of different harvesting times on some silage quality of maize, sorghum and sorghum-sudangrass hybrids grown as in a split plot design with 3 replicates during second crop in semi arid condition were evaluated. In this research, whole plant silage chemical composition and DM digestibilities on different times, measured in vivo were determined. For this purpose, 2 maize (DK 711, TTM 815), 2 sorghum (Sucro sorgo 506, FS 5) and 2 sorghum-sudangrass hybrids (P 988, Grazer N2) cultivars were harvested at 3 different maturity stages (mid-flowering-MF, milkline-ML and hard dough-HD). The chopped materials were ensiled in 10 L anaerobic jars, for 60 days. Silage samples were dried (CP, FP, pH, ADF, NDF contents were measured) and incubated in fistulated 3 Holstein Friesian heifers for determining dry matter digestibility. Significant differences were found between plant cultivars and harvesting stages for all investigated parameters. The dry matter yields varied between 1265.42 and 253.401 kg ha⁻¹. The highest dry matter yield was obtained from Sucro Sorgo 506 with ML and HD. Dry matter content of silages were changed from 20.63% (in silage sorghum cv. FS 5) to 27.36% (in sorghum-sudangrass hybrids cv. Grazer N2), pH (3.84 in FS 5 and 3.98 in TTM 815), Fleig point (FP) (90.87 in TTM 815 and 104.6 in Grazer N2), Crude Protein (CP) was 3.92% in Grazer N2 and 6.64% in FS 5, ADF was 44.56% in DK 711 and 49.33% in SS 506, NDF was 59.56% in DK 711 and 65.70% in P 988, whereas in vivo DM digestibility at 12 h was 32.82% in SS 506 and 38.91% in TTM 815. Crop maturity increased statistically significantly, silage DM varied from 20.43-25.92% and in vivo digestibility of DM at 12 h varied from 32.56-37.66%, however significantly decreased. ADF decreased from 61.71-42.56%, NDF decreased from 64.71-59.62%, WSC (Water Soluble Carbohydrates) increased from 24.59-30.24%. CP decreased from 5.59-5.05% pH was between 3.78-4.10 and Fleig point was between 94.66-97.58. These values were not changed statistically, when crop maturity increased. Incubation periods were 0, 12, 24, 48 and 72 h for determining dry matter digestibility by using nylon bag technique. Silage NDF values were decreased from flowering to milkline stages. It was concluded that silages in vivo DM digestibility were increased with maturity at 12 h rumen incubation.

Key words: Maize, sorghum, yield, NDF, ADF, Nylon bags, digestibility

INTRODUCTION

Ensiling is a common preservation method especially in unfavorable climates because of difficulties in drying forage crops. The stage of maturity at harvesting is a major factor in determining silage digestibility (Johnson et al., 1999). As the crop develops, starch is accumulated in the grain with a decline of digestibility in the stover fraction of the plant (Daynard and Hunter, 1975; Struik et al., 1985). Crop maturity decreases NDF content significantly (0.60-041 DM), without affecting DM digestibility (0.57) (Di Marco et al., 2002). In vivo dry matter digestibility of silage remains constant with maturity because the depression in NDF digestibility was compensated by starch accumulation in the grain.

The ability to manage corn silage to maximize the nutritive value of the crop is important. Maturity of corn silage had an impact on DM recovery and feedable DM (Johnson et al., 2002).

Corresponding Author: Ismail Gul, Department of Field Crops, Faculty of Agriculture, University of Dicle, 21280 Diyarbakir, Turkey
Whole crop maize is the major crop ensiled in Turkey. The stage of maturity at harvest is a major factor in determining the nutritive value of maize silage. Johnson et al. (1999) have reported that the largest changes in nutritive components in the maize plant occurred in the early stages of maturity. At the Early Dent (ED) stage, Dry Matter (DM) content was low and Water Soluble Carbohydrate contents were (WSC) high, but with no decrease in digestibility. At the blackline (BL) stage, DM yields are the highest, but the WSC decrease sharply owing to starch accumulation and this had an impact on the ensiling quality of the maize. Adams (1995) has reported that concentrations of Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) in whole crop maize silage decreased as maturity proceeded from ED to 2-3rd Milk Line (ML) stage, but did not change from 2-3rd ML to the BL stage. Buck et al. (1969), Bal et al. (1998) and Johnson et al. (2001) found that NDF and ADF concentrations in whole crop maize silage decreased as maturity proceeded from the milk and ED to the BL stage. Hunt et al. (1989) found that despite declining NDF and ADF content, in situ rumen DM degradability decreased progressively from early (603 g kg\(^{-1}\)) to late (564 g kg\(^{-1}\)) maturity. Russel et al. (1992) reported that in vitro DM degradability of maize silage decreased with advancing maturity and was highly correlated with ADF and lignin contents. Harvesting maize at BL stage resulted in decreased starch digestibility when compared with maize harvested at 2-3rd ML and one-half ML stages (Harrison et al., 1996). In recent studies with whole crop maize, the contents of WSC, NDF, ADF and Crude Protein (CP) tended to decline and DM and starch increase, with advancing maturity (Bal et al., 1997, 1998; Johnson et al., 2001). However, relationships between maturity of maize silage and DM intake, milk production, milk component yield and digestibility of nutrients were not consistent (Johnson et al., 1999).

Sorghum is becoming an increasingly important forage crop in many regions of the world due to its high productivity and ability to utilize water efficiently even under drought conditions (Zerbini and Thomas, 2003; Sanchez et al., 2002). Its high resistance to drought makes it a suitable crop for semi-arid areas (Tabosa et al., 1999), especially in light of its higher productivity under dry conditions when compared to corn (Tabosa et al., 1986). The major selection criteria for improving forage nutritional value are increased in vitro DM digestibility (IVDMD) and reduced lignin content (Casler, 2000). Expanding the use of sorghum as a forage crop obliges to overcome its tendency to lodging that characterizes the tall types especially under irrigation (Reddy et al., 1999; Miron et al., 2005). Another obstacle to expanded use of tall forage sorghums is their insufficient accumulation of DM content, as proper accumulation is a precondition for successful ensiling (Carmi et al., 2005; Miron et al., 2005, 2006).

Such improvements may be promoted by genetic breeding and selection, choosing the optimal stage for harvest (Carmi et al., 2005; Miron et al., 2006), and improving growth factors, such as irrigation level and plant density. Improving the nutritive value of forage sorghum for productive ruminants is an important goal (Defoor et al., 2001).

Improvement of forage sorghum productivity by breeding obliges to focus on traits that might affect the yield and nutritive quality of the forage. Such a trait is the resistance to lodging that had become an important target to breeders (Rosenow, 1977; Buttler and Muir, 2003). It is suggested that a minimum DM content of 247 g kg\(^{-1}\) to ensure a margin of safety against production of effluent. Ensiling sorghum biomass with DM content below this level may result in high chance of spoilage and dry matter loss during ensilage (Savoie and Joffret, 2003). Another trait of importance, as related to livestock feeding, is high digestibility of silage DM and Neutral Detergent Fiber (NDF). Sorghum forage, especially of BMR varieties, may have high nutritive value, which might be comparable to that of corn (Bean et al., 2002; Hanna et al., 1981).

New sorghum varieties were recently used in field tests in Israel and demonstrated promising forage yield (Kipnis et al., 2001). However, there is still lack of knowledge in the literature about the ensilage characteristics of these new varieties, including: Cell wall polysaccharides, Crude Protein (CP) and Water Soluble Carbohydrate (WSC) content and their participation in the ensilage process, profile of fermentation end-products, silage pH and silage digestibility. There are areas where limited rainfall or unfavourable soil conditions make corn production uncertain. Because of its drought tolerance and high forage production, sorghum is an alternative (Andewawakun et al., 1989), thereby providing the opportunity to increase the areas where ensilage crops can be produced. The most important factors which define sorghum silage quality are grain content (Young et al., 1996) and stage of maturity (Bolsen, 2004). The major potential limitation of SS is the lower digestibility of grain due to the dense proteinaceous matrix in the peripheral endosperm layer of the kernel (Gutierrez et al., 1982), which renders starch granules inaccessible to digestion in the rumen. There is little experimental information that evaluates replacement of CS by SS as a supplement to growing steers under grazing conditions.

Gucuk and Baytek (1999) illustrated that the dry matter yields increases as harvesting time is delayed and
that the yields must be harvested during their dough stage. Hamed and Mohamed (1987) based on a study where they explored the 3 harvesting periods, concluded that the silage sorghum that is harvested during dough stage is more productive than those harvested during the other 2 periods; Manga et al. (1991), for maize that was harvested in 4 different stages, showed that the biomass and dry matter yield increases as the harvesting time is delaying; Miaki et al. (1991), found out that the nourishment values of maize and silage sorghum is similar after they compare the nourishment value of maize that was harvested during hard dough stage and silage sorghum that was harvested during hard dough stage.

The objective of this study was to evaluate the effect of maturity and compare maize, sorghum and sorghum × sudangrass hybrid whole-plant silages and digestibility of the silages.

**MATERIALS AND METHODS**

**Field trials:** Field trials were conducted during the semi-arid region over 2 years (2001 and 2002) at the Southeastern Anatolian Regional Agricultural Research Institute Implementation area in Diyarbakir (37° 54’N, 40° 14’E altitude 660 m above mean sea level). The average annual temperature is 15.8°C, rainfall is 481.6 mm and the average relative humidity is about 53.8%. The average temperature can reach 30°C in July and August. The lowest average temperature can be 7°C in December and January. Experimental design was a split-plot randomised complete block design with 3 replications. The crops treatments were main plots and harvesting times were sub-plots. Trial experimental pan were sown at 9 July for first year and 14 July for second year. Plant population was approximately 142840 plants ha⁻¹ in maize, 150000 plants ha⁻¹ in sorghum and sorghum sudangrass hybrids. All plots were irrigated at 10 day intervals according to plant phenological throughout the season.

**Crops and silo filling:** Forages harvested and chopped to about 1.5 cm on 3 dates at approximately 2 week intervals during second cropping season. The chopped silage materials were ensiled in 10 L jars as 3 replicates for each cultivars and maturing stages. Each jar was filled approximately 9000 g wet weight basis, without space. There were 18 jars for each maturing stages and a total of 54 jars. At the end of the ensiling period (60 days), silage jars were opened and physically examined, dried and incubated in rumen for ruminal degradability trial.

**Analytical procedures:** Silage samples were dried at 70°C for 48 h and ground (1 mm). Chemical analyses were triplicated. The DM content of the crops and silages were determined by drying in a special fan-assisted drying cabin. Silages pH levels were measured in filtrated silage water (Folan et al., 1998). The Fleig points of the silages were calculated by the following equation as reported by Kilic (1984);

\[
\text{Fleig points} = 220 + (2 \times \text{DM\% - 15}) - 40 \times \text{pH}
\]

where, Fleig points denote the values between 85-100 very good quality; 60-80 good quality, 55-60 moderate quality; 25-40 satisfying quality and <20 worthless.

Crude protein contents of samples were analysed by Leco 528 analyzer, ADF and NDF were analyzed using sodium sulphite addition (Van Soest et al., 1991).

**In vivo digestibility measurements:** Dry matter degradabilities of forages were determined using 3 fistulated Holstein heifers for 0, 12, 24, 48 and 72 h. Samples were placed in 7.5±15.5 cm bags made of dacron, pore size 40 μ, which were inserted into rumen of 3 fistulated Holstein heifers fed on alfalfa forage-based diet. The dacron bags were incubated in the rumen for up to 72 h.

**In vivo DM digestibilities of silages were determined according to the procedure described by Tilley and Terry (1963) as modified by Marten and Barnes (1980). WSC contents were determined under water by 5 g silage which were dried and put in to dacron bags. The dacron bags were kept under tape water until it become clear. After that bag, were kept at 70°C for 48 h and weighed, the difference was used for these criteria.

**Statistical analysis:** The trial was arranged according to split plots design by 3 replicates. The means were compared using Fisher’s least significant differences. Digestibility trial was done according to 3×3 latin square method by 3 replicates (Düzgüneş, 1983). Differences were evaluated considering Duncan Test (1955).

**RESULTS AND DISCUSSION**

Effects of different plant cultivar silages and their maturity stages on DM yield, DM, CP, ADF, NDF, WSC, pH and FP contents are presented in Table 1 and 2.

**Dry matter yield:** There were statistically significant differences among sorghum × sudangrass hybrids to sorghum and maize cultivars for dry matter yield. The dry matter yield values ranged from 1268.2 and 25340.1 kg ha⁻¹ for the 2 years average results (Table 1). The highest values attained from cv. Sucro Sorgo 506.
Table 1: DM Yield, CP, ADF, NDF contents of different cultivars according to harvesting stages

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Harvesting stage</th>
<th>DM Yield (Kg/ha⁻¹)</th>
<th>CP (%)</th>
<th>ADF (%)</th>
<th>NDF (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTM 815</td>
<td>MF</td>
<td>13161.7±837 g</td>
<td>7.12±0.29 a</td>
<td>50.83±1.30</td>
<td>62.06±0.58</td>
</tr>
<tr>
<td></td>
<td>ML</td>
<td>16441.6±1307 ef</td>
<td>5.88±0.61 bc</td>
<td>43.06±1.04</td>
<td>60.81±0.66</td>
</tr>
<tr>
<td></td>
<td>HD</td>
<td>16885.5±1818 ddef</td>
<td>5.02±0.96 cde</td>
<td>42.83±0.60</td>
<td>60.20±1.56</td>
</tr>
<tr>
<td>DK-711</td>
<td>MF</td>
<td>12654.2±794 g</td>
<td>7.24±0.51a</td>
<td>49.17±2.49</td>
<td>60.36±2.54</td>
</tr>
<tr>
<td></td>
<td>ML</td>
<td>14560.6±454 fg</td>
<td>5.54±0.46 bc</td>
<td>46.59±3.18</td>
<td>63.28±2.42</td>
</tr>
<tr>
<td></td>
<td>HD</td>
<td>15178.8±935 ef fg</td>
<td>5.90±0.56 bc</td>
<td>38.09±1.26</td>
<td>55.03±1.49</td>
</tr>
<tr>
<td>S.S 506</td>
<td>MF</td>
<td>17641.9±1358 df</td>
<td>3.77±0.58 def</td>
<td>50.59±3.12</td>
<td>66.08±3.26</td>
</tr>
<tr>
<td></td>
<td>ML</td>
<td>24790.1±2692 a</td>
<td>4.68±0.91 c-f</td>
<td>48.59±2.50</td>
<td>64.32±1.97</td>
</tr>
<tr>
<td></td>
<td>HD</td>
<td>25340.1±1581 a</td>
<td>4.53±0.68 c-f</td>
<td>49.06±3.50</td>
<td>65.39±1.94</td>
</tr>
<tr>
<td>FS-5</td>
<td>MF</td>
<td>16764.9±520 def</td>
<td>5.72±0.63 bc</td>
<td>50.04±1.01</td>
<td>66.96±0.95</td>
</tr>
<tr>
<td></td>
<td>ML</td>
<td>22381.4±1166 ab</td>
<td>6.70±0.81 ab</td>
<td>56.00±2.09</td>
<td>61.77±3.42</td>
</tr>
<tr>
<td></td>
<td>HD</td>
<td>23651.6±1406 ab</td>
<td>7.50±0.69 a</td>
<td>38.83±0.73</td>
<td>56.63±2.70</td>
</tr>
<tr>
<td>P-988</td>
<td>MF</td>
<td>16502.8±862 ef</td>
<td>5.03±0.14 cd</td>
<td>52.14±1.09</td>
<td>68.00±0.66</td>
</tr>
<tr>
<td></td>
<td>ML</td>
<td>19701.0±1133 cd</td>
<td>4.79±0.10 c-f</td>
<td>47.00±1.75</td>
<td>69.69±1.85</td>
</tr>
<tr>
<td></td>
<td>HD</td>
<td>21671.6±1223 bc</td>
<td>4.42±0.63 c-f</td>
<td>44.00±5.22</td>
<td>60.71±3.07</td>
</tr>
<tr>
<td>Grazer N2</td>
<td>MF</td>
<td>15143.7±939 efg</td>
<td>4.66±0.30 c-f</td>
<td>48.52±2.62</td>
<td>64.82±1.93</td>
</tr>
<tr>
<td></td>
<td>ML</td>
<td>17948.0±453 de</td>
<td>3.63±0.30 ef</td>
<td>47.33±1.36</td>
<td>64.13±3.02</td>
</tr>
<tr>
<td></td>
<td>HD</td>
<td>18151.8±292 de</td>
<td>3.46±0.63 f</td>
<td>42.67±1.36</td>
<td>59.76±1.63</td>
</tr>
</tbody>
</table>

Within a column, means followed by a different letter different (p<0.05)

Table 2: DM, WSC, pH Content and Fleig Point Values of Different Cultivars According to Harvesting Stages

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Harvesting stage</th>
<th>DM (%)</th>
<th>WSC (%)</th>
<th>pH</th>
<th>Fleig Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTM 815</td>
<td>MF</td>
<td>20.40±0.97 de</td>
<td>25.77±1.27 c-f</td>
<td>3.77±0.09</td>
<td>95.12±5.46</td>
</tr>
<tr>
<td></td>
<td>ML</td>
<td>23.54±0.76 cd</td>
<td>26.59±1.20 cde</td>
<td>3.90±0.10</td>
<td>96.07±5.23</td>
</tr>
<tr>
<td></td>
<td>HD</td>
<td>23.54±0.66 cd</td>
<td>31.22±1.20 ab</td>
<td>4.27±0.22</td>
<td>81.42±4.06</td>
</tr>
<tr>
<td>DK-711</td>
<td>MF</td>
<td>18.21±1.76 e</td>
<td>29.09±1.41 bcd</td>
<td>3.77±0.12</td>
<td>90.75±2.96</td>
</tr>
<tr>
<td></td>
<td>ML</td>
<td>18.27±0.48 e</td>
<td>24.01±1.52 efg</td>
<td>3.90±0.10</td>
<td>85.54±4.84</td>
</tr>
<tr>
<td></td>
<td>HD</td>
<td>27.87±0.74 ab</td>
<td>34.91±0.78 a</td>
<td>4.03±0.03</td>
<td>99.41±2.78</td>
</tr>
<tr>
<td>S.S 506</td>
<td>MF</td>
<td>18.88±0.61 e</td>
<td>21.32±1.32 g</td>
<td>3.87±0.09</td>
<td>88.16±4.74</td>
</tr>
<tr>
<td></td>
<td>ML</td>
<td>24.66±3.04 bc</td>
<td>26.04±1.34 c-f</td>
<td>3.87±0.07</td>
<td>99.65±3.04</td>
</tr>
<tr>
<td></td>
<td>HD</td>
<td>22.74±0.29 cd</td>
<td>25.77±2.31 c-f</td>
<td>4.10±0.06</td>
<td>86.47±2.89</td>
</tr>
<tr>
<td>FS-5</td>
<td>MF</td>
<td>18.92±1.29 e</td>
<td>25.48±1.03 def</td>
<td>3.73±0.03</td>
<td>93.50±3.53</td>
</tr>
<tr>
<td></td>
<td>ML</td>
<td>21.53±1.75 d</td>
<td>29.71±2.50 bc</td>
<td>3.77±0.04</td>
<td>97.46±4.41</td>
</tr>
<tr>
<td></td>
<td>HD</td>
<td>21.44±0.88 cde</td>
<td>26.91±1.55 cde</td>
<td>4.03±0.07</td>
<td>86.54±4.42</td>
</tr>
<tr>
<td>P-988</td>
<td>MF</td>
<td>21.81±1.30 cde</td>
<td>23.39±0.96 efg</td>
<td>3.80±0.06</td>
<td>96.63±4.83</td>
</tr>
<tr>
<td></td>
<td>ML</td>
<td>27.68±0.75 ab</td>
<td>25.50±0.86 def</td>
<td>3.97±0.12</td>
<td>101.78±5.88</td>
</tr>
<tr>
<td></td>
<td>HD</td>
<td>29.86±1.02 a</td>
<td>29.64±3.14 bc</td>
<td>4.13±0.09</td>
<td>99.35±5.51</td>
</tr>
<tr>
<td>Grazer N2</td>
<td>MF</td>
<td>24.40±1.78 bc</td>
<td>22.52±1.20 fg</td>
<td>3.73±0.07</td>
<td>104.46±3.13</td>
</tr>
<tr>
<td></td>
<td>ML</td>
<td>27.63±0.15 ab</td>
<td>24.75±1.24 efg</td>
<td>3.87±0.07</td>
<td>105.59±2.00</td>
</tr>
<tr>
<td></td>
<td>HD</td>
<td>30.06±1.59 a</td>
<td>32.97±1.52 ab</td>
<td>4.03±0.03</td>
<td>103.78±2.92</td>
</tr>
<tr>
<td>C.V (%)</td>
<td></td>
<td>16.78</td>
<td>15.78</td>
<td>8.61</td>
<td>5.97</td>
</tr>
<tr>
<td>LSD (%)</td>
<td></td>
<td>2770</td>
<td>1.39</td>
<td>ns</td>
<td>ns</td>
</tr>
</tbody>
</table>

Crude protein: There were statistically significant differences among cultivars for crude protein contents. The highest CP content of 6.64% was obtained in FS-5 and lowest 3.92% in cv.Grazer N2 (Table 1). CP contents of other cultivars took place between these 2 cultivars. There was no significant effect of harvesting stages on crude protein contents. When we compare cultivar×harvesting stage interaction, maize cv. have highest CP levels in mid-flowering stage, sorghum cultivars have highest CP levels in ML an HD stages, but sorghum×sudangrass hybrids in each stage have the lowest CP and these differences were statistically significant.

ADF: There were no statistically significant difference between cultivars for ADF and NDF content the lowest ADF contents of silages were obtained in DK-711 as 44.56 and the highest 49.33% was obtained in Sucro sorgo 506 cultivars (Table 1). However, considering harvest stage, there were statistically significant differences between harvesting stages. The highest ADF content of silages were 50.17% at mid-flowering stage and the lowest value of 42.56% at HD stages. In MF stages, there was no cob on plant and after this stage, ADF content of maize grain leads to lower ADF content of silage. This finding is in accordance with the findings of Coors et al. (1997).

silage sorghum, while the lowest results are from the cv. DK 711 silage maize. In all cultivars, DM yield of plants were increased to considering maturity stages. Dry matter yield of these plants were increased by developing maturity stages (Gucuk and Baytekin, 1999, Manga et al., 1991).
NDF: The highest NDF content of 65.80% was obtained in cv. P 988 and the lowest was 59.56% in cv. DK-711 (Table 1). However, considering harvesting stages, there were significant differences between harvesting stages. The highest NDF content of 64.71% was obtained in MF stage and the lowest NDF of 59.62% in HD stages. NDF contents of silages decreased when harvesting time delayed from MF to HD stages. This result is similar to the results of Coors et al. (1997).

DM content: As shown in Table 2, silage DM content increased from 18.21 in DK 711 cultivar at MF stage to 30.06 in Grazer N2 cultivar at HD stage. There were statistically significant differences among sorghum-sudangrass hybrids to sorghum and maize cultivars for silage DM. In all cultivars, DM contents of silages were increased to considering maturity stages. Dry matter contents of these plants were increased by developing maturity stages (Iptás and Avçoğlu 1997, Heath et al., 1985).

Water Soluble Carbohydrate Content (WSC): There were no statistically significant differences for water soluble contents between cultivars except harvesting stages. Water soluble contents were obtained by soluble dry matter in water (carbohydrate, protein etc.). As seen in Table 2, WSC values were increased from (24.59)-(30.24) at HD stages. Some authors stated that plant doesn’t accumulate enough carbohydrates before ML stage and this leads to less carbohydrates for lactic acid bacteria. Soluble carbohydrate content was the lowest in early stages (MF) with increased levels in ML and HD stages. Our findings are in parallel with the findings of Aşıkgoz, (1995) and Coors et al. (1997).

pH value: There were no significant differences between cultivars and harvesting stages for silage pH levels. Silage pH values changed from 3.84 in FS 5-3.98 in TTM 815 (Table 2). Our pH values of silages were in similar lines with the findings of Gaggiotti et al. (1992). pH values of silages were increased when harvesting time delayed. All values obtained in this experiment were in the range of good quality silage pH values.

Pleg Points (FP): There were statistically significant differences between cultivars for silage FP levels. Silage FP values were changed from 90.84 in TTM 815-104.06 in Grazer N2 for cultivars, but from 94.66 in MF to 92.84 in HD stages (Table 2). Also, all silages were in very good quality according to the fleig point scale.

In vivo digestibility of DM: In vivo DM digestibilities of silages at 12 and 14 h were statistically significant among cultivars the highest DM digestibility value of 38.91% was obtained in cv. TTM 815 and the lowest 32.82% was obtained in Sucro Sorgo 506 cultivars (Fig. 1). After 24 h incubation, the highest value of48.90% was obtained in DK 711, the lowest was 38.38% in cv. Sucro Sorgo 506. After 48 and 72 h incubation, there were not statistically significant (p>0.05). Differences between cultivars However, in vivo DM digestibility values were increased with maturity. In vivo DM digestibility values were in the range of 50.31 in TTM-815 and 57.63 in P-988 as reported by Muller et al. (1972), however higher values have also been reported by Rook et al. (1977), Oba and Allen (1999) and Tjardes et al. (2000) in the range of 60-70% and Deinum et al. (1984) in the range of 82-89%. In accordance with findings of Bal et al. (1997) and Johnson et al. (1999), in vivo DM digestibility was not affected by the stage of maturity (MF, ML and HD stages) at 24, 48 and 72 h, except at 12 h. It could be speculated that over than 12 h period of incubation used in this procedure, might have exceed the time period that silages were retained in the Rumen for in vivo digestion. Soluble carbohydrates and proteins might have ingested up to 12 h. At 12 h, the highest DM digestibility was obtained 37.66% in HD stage, the lowest was 32.56% in MF stage.

![Fig. 1: In vivo rumen DM degradability of the ensiled-plants after 60 days of ensiling](image-url)
CONCLUSION

Dry matter yields of crops and DM contents, pH and FP values of silages were increased when harvesting time delaying. NDF contents were similar for maize, sorghum and sorghum × sudangrass hybrid silages. NDF content was increased from MF to ML stages. Harvesting stages were not affected silage CP content. Soluble DM contents were increased from MF to ML stages. At 24 h rumen incubation, DM digestibilities of maize cultivars were higher than sorghum and sorghum × sudangrass hybrids. Harvesting the crop at earlier stages than HD, reduced DM content, pH and FP values but improved CP, ADF and NDF content.

ACKNOWLEDGEMENT

This study is a part of the project TAGEM/TA/GY /001/14/035 which is supported by the Ministry of Agriculture (Turkey).

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