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Quality Properties of Forage Maize and Sweet Sorghum Silage at Different Harvest Stages

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ABSTRACT: The present study conducted during *kharif* 2022 on sandy loam soil of ARI, AICRP on Forage Crops and Utilization, Rajendranagar, Hyderabad. The experiment was laid out in randomized block design with factorial concept with factor (A) as six varieties (four fodder maize varieties: African tall, J-1006, TSFM 15-5 and DHM-117 and two sweet sorghum varieties: CSH-22SS and CSV-49SS) and factor (B) as three phenophases/harvest stages (milky stage, soft dough stage and dent stage for maize/hard dough stage for sorghum) with three replications. The test crops were sown on 25th July 2022 adopting spacing of 30 cm × 10 cm. In terms of silage quality, fodder maize variety (J-1006) recorded significantly higher moisture content, lactic acid concentration and desirable pH. On the other hand, crude protein content of silage across varieties was on par with each other. While, crude protein yield was higher for African tall variety. Sweet sorghum variety (CSH-22SS) recorded higher TSS and African tall recorded higher ADF and NDF content. The silage quality parameters (pH and crude protein yield) increased as the crop advanced towards maturity. On the other hand, crude protein content, moisture content and TSS of silage decreased from milky stage to dent stage. ADF and NDF content in silage were higher in the crop ensiled at dent stage. It can be concluded that, among six fodder varieties tested, fodder maize variety (J-1006) registered significantly superior silage quality parameters.

Keywords: Silage, Forage Maize, Sweet Sorghum, pH, lactic acid.

INTRODUCTION

The demand for green fodder requirement in Telangana state is 63.74 Lakh tonnes while, the availability is only 23.77 lakh tonnes. Hence, there is deficit of 39.97 lakh tonnes of green fodder which accounts to 62% (NIANP, 2017). In order to fill the gap between supply and demand, measures have to be taken to increase the green fodder supply and methods to preserve the green fodder for future use during the off season.

For dairying to be successful there must be year-round fodder supply. In India farmers commonly face an acute shortage of green fodder twice a year particularly during the months of Nov-Dec and May-June (lean periods). During this period the farmers have to depend solely on straw and stover along with the costly concentrates to fulfil the daily dietary requirements of cattle. The straw or stover are not nutritious feed and are often deficient in some vital nutrients and hence, reduce the milk production potential of the cattle. Therefore, it is crucial to produce and conserve forages in sufficient quantity and of good quality. Conserved forage is needed to maintain milk production over the dry months as well.

Forage conservation plays a vital role in ensuring the productivity and efficiency of ruminant livestock farms. It offers a reliable supply of quality feed during periods of low forage production or dormancy. Additionally, it allows farmers to preserve excess forage when its growth exceeds the grazing animal's immediate needs, preventing it from becoming overly mature and less nutritious. As a result, forage conservation ensures a consistent and high-quality feed supply for ruminants. In livestock production regions, seasonal variations in climate lead to varied production of forages throughout the year depending on climatic parameters. Hence, for regular supply of quality feed to livestock during the off season, crop has to be harvested at ideal stage and conserved as silage. Silage plays a crucial role in filling the wide gap in availability and requirement of quality green forages for animals.

Ensiling is a widely used preservation method for moist forage crops. It involves the anaerobic fermentation to create silage, a type of feed that can be stored for extended periods while, retaining much of its nutritional value. Ensiling relies on the activity of lactic acid bacteria (LAB), which operate in an oxygen deprived environment, to transform water-soluble carbohydrates (WSC) within the forage crops into organic acids, predominantly lactic acid. This process occurs under anaerobic conditions, leading to a reduction in pH level. Consequently, the decreased pH impedes the proliferation of spoilage microorganisms, contributing to the preservation of the forage material (Mc Donald *et al*.1991). In these conditions, lactic acid bacteria, converts some of the sugars in the plant into the pleasant tasting lactic acid over undesirable bacteria such as clostridia which produce butyric acid, which is unpalatable to livestock and molds that cause rotting of the silage. A good silage has sweet smell and cattle, goats and sheep readily relish it. Silage can be made quite cheaply and easily, provided when done in a correct way duly following standards.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* (25th July, 2022) at AICRP on Forage Crops and Utilization, Agricultural Research Institute, Rajendranagar, Hyderabad, Telangana, India. Experiment was designed with the objective of evaluating the silage quality of for age maize (*Zea mays*) and sweet sorghum (*Sorghum bicolor L. Moench*) varieties harvested at different phenophases. The experiment was laid out in Factorial randomized block design (FRBD) with two factors and 18 treatment combinations *viz*; (Factor A: six varieties: V_1: African tall, V_2: J–1006, V_3: TSFM15-5 and V_4: DHM-117, V_5: CSH-22SS, V_6: CSV-49SS) and (Factor B: 3 Stages: S_1: Milky stage, S_2: Soft dough stage and S_3: Dentstage - maize/ hard dough stage – sweet sorghum) and replicated thrice. The soil was sandy loam, neutral in pH (7.0) and low in available nitrogen, medium in available phosphorous and potassium. Nitrogen was applied in three splits in the form of urea (60N kgha^{-1} basal; 30kgNha^{-1} 30DAS; 30kg Nha^{-1} 60DAS), Phosphorous (40 kg P_2O_5ha^{-1}) and potassium (30 kgK_2Oha^{-1}) as basal application. The crop was sown with inter row spacing of 30cm and ensiled samples at three stages (milky, soft dough and dent/ hard dough stage) were shade dried for two to three days before oven drying (60°C) to attain constant weight. On weight basis dry-matter was calculated and the chemical analysis was done for dried and powdered silage samples. Data obtained was statistically analyzed as mentioned by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Silage quality parameters

(i) pH. The data pertaining to the pH of silage prepared from different varieties and at phenophases are presented (Table 1). Significant variation was observed among varieties and phenophases in terms of pH of silage and the interaction was found to be significant.

Silage of fodder maize variety J-1006 recorded significantly lower pH (3.9) followed by sweet sorghum variety CSH-22SS (4.0) and significantly higher pH (4.3) was recorded by DHM-117. While, the pH of African tall and CSV-49SS varieties were significantly comparable with each other (4.2). Among the three phenophases of harvest, milky stage recorded significantly lower pH (3.8) followed by soft dough (4.0) and dent stage (4.6) respectively in terms of silage. The interaction between varieties and phenophases was found to be significant. Silage prepared from variety J-1006 at milky stage recorded significantly lower pH (3.6) followed by CSH-22SS at milky stage (3.7). Significantly higher pH of silage (4.9) was recorded with African tall variety harvested at dent stage. The pH of silage increased towards crop maturity due to higher concentration of water-soluble concentrates, lactic acid concentration and more extensive fermentation. Hence, low pH was found at early maturity stage (milk stage) as compared to soft dough and dent stages respectively (Faria junior *et al*., 2011).

(ii) Crude protein content (%). Significant variation was observed among phenophases in terms of crude protein. However, no significant difference was observed among varieties as well as due to their interaction on crude protein content.

Crop ensiled at milky stage recorded significantly higher crude protein content (6.2%) followed by soft dough (5.3%) and dent stage (4.7%) respectively (Table 1).

(iii) Crude protein yield (q ha^{-1}). Among the varieties tested, fodder maize African tall silage recorded significantly higher crude protein yield (5.03 q ha^{-1}) followed by sweet sorghum CSH-22SS silage (4.56 q ha^{-1}) and significantly lower crude protein yield (4.29 q ha^{-1}) was recorded by CSV-49SS.There were no significant differences among phenophases and also due to the interaction of varieties and phenophases in terms of crude protein yield (Table 1).

(iv) Moisture content (%). Significant variation was observed among varieties as well as at different phenophases in terms of moisture content of silage and the interaction was also found to be significant.

Among the varieties tested, silage prepared from fodder maize variety J-1006 recorded significantly higher moisture content (68.0%) and silage from TSFM 15-5 and CSH-22SS recorded significantly comparable moisture content (67.1%) were on par with J-1006. On the other hand, significantly lower moisture content (61.8%) was recorded by DHM-117. Among three phenophases of harvest, crop ensiled at milky stage recorded significantly higher mean moisture content (69.2%) followed by soft dough stage (65.2%) and significantly lower moisture content (61.8%) was recorded by silage prepared at dent stage. Lower dry matter content and high water-soluble carbohydrates at milky stage reflects high moisture content at milky stage compared to soft dough and dent stages (Bal *et al*., 1997). The interaction among varieties and phenophases was found to be significant. Ensiled variety J-1006 at milky stage recorded significantly higher moisture content (70.2%) followed by CSH-22SS at milky stage (70%). Significantly lower moisture content (57.1%) was recorded by DHM-117 at dent stage.

(v) Total soluble sugars (%). Significant variation was observed among varieties and phenophases in terms of TSS in silages but, the interaction was found to be non-significant.

In terms of total soluble sugars, CSH-22SS recorded significantly higher total soluble sugars (8.8%) followed by J-1006 (8.5%) and significantly lower TSS (7.1%) was recorded by DHM-117. Among three phenophases, crop ensiled at milky stage recorded significantly higher TSS (8.1%) followed by soft dough (7.9%) and dent stage (7.6%) respectively. On the other hand, the interaction between varieties and phenophases was found to be non-significant (Table 1).

(vi) Acid detergent fiber (%). The data pertaining to acid detergent fiber of silage prepared from varieties and phenophases are presented (Table1). Data revealed that significant variation due to varieties and phenophases in terms of ADF in silages. However, the interaction between varieties and phenophases was found to be non-significant.

Among the varieties tested, African tall recorded significantly higher ADF (44.3%) followed by TSFM 15-5 (42.6%) and significantly lower ADF (36.1%) was recorded by CSV-49SS. ADF content reduced after ensiling due to breakdown of hemi cellulose at low pH during ensiling, reflected in lower ADF content of silage as compared to the actual ADF content in crop (Filya, 2004). Crop ensiled at dent stage recorded significantly higher mean acid detergent fiber (43.4%) followed by soft dough (40.8%) and milky stage (37.2%) respectively. The interaction effect was found to be non-significant.

(vii) Neutral detergent fiber (%). Significant variation was observed among varieties and phenophases in terms of NDF in the silage and the interaction was also found to be significant.

With respect to neutral detergent fiber, fodder maize silage African tall recorded significantly higher NDF (63.7%) followed by J-1006 (62.6%) and significantly lower NDF (50.5%) was recorded by DHM-117. Among the phenophases, crop ensiled at dent stage recorded significantly higher NDF (61.6%) followed by soft dough stage (59%) and milky stage (57.3%) respectively. The interaction between varieties and phenophases was found to be significant. CSH-22SS at dent stage recorded significantly higher NDF (66.8%) followed by African tall at milky stage (65.9%). On the other hand, significantly lower NDF (50.9%) was recorded by DHM-117 at soft dough stage.

(viii) Lactic acid (%). Significant variation was observed among varieties and phenophases in terms of lactic acid in silage and the interaction was also found to be significant.

Among the varieties tested, fodder maize variety J-1006 recorded significantly higher mean lactic acid concentration (3.2%) while, CSH-22SS (3.1%) was on par with J-1006 in terms of silage. While, significantly lower lactic acid concentration (1.7%) was recorded by DHM-117. Among the phenophases, crop ensiled at milky stage recorded significantly higher lactic acid concentration (3%) followed by soft dough (2.8%) and dent stage (2.2%) respectively. Higher lactic acid concentration was found at milky stage due to higher water-soluble carbohydrates at milky stage, reflected in higher lactic acid concentration (Filya, 2004). The interaction effect of varieties and phenophases was found to be significant. J-1006 recorded significantly higher lactic acid concentration harvested at milky stage (3.5%) followed by CSH-22SS at milky stage (3.4%). Significantly, lower lactic acid concentration (1.7%) was recorded by DHM-117 harvested at dent stage (0.8%).

Table 1: Effect of different varieties and harvest stages on silage quality of fodder maize and sweet sorghum.

Treatments	pH	CP%	CPY (q ha^{-1})	Moisture content (%)	TSS%	ADF%	NDF%	Lactic acid (%)
Varieties (V)								
African tall	4.20	5.4	5.03	64.8	7.4	44.3	63.7	2.50
J-1006	3.90	5.6	4.43	68.0	8.5	38.6	62.2	3.20
TSFM 15-5	4.10	5.3	4.47	67.1	7.5	42.6	58.2	2.50
DHM-117	4.30	5.4	4.39	61.8	7.1	41.3	50.5	1.70
CSH 22SS	4.00	5.4	4.56	67.1	8.8	39.9	60.7	3.10
CSV 49SS	4.20	5.2	4.29	63.6	7.8	36.1	60.5	3.00
S Em±	0.03	0.1	0.15	0.5	0.1	0.4	0.5	0.03
CD(P=0.05)	0.10	NS	0.44	1.5	0.2	1.2	1.4	0.10
Phenophases (P)								
Milky stage	3.80	6.2	4.44	69.2	8.1	37.2	57.3	3.00
Softdough stage	4.00	5.3	4.56	65.2	7.9	40.8	59.0	2.80
Dent stage	4.60	4.7	4.59	61.8	7.6	43.4	61.6	2.20
S Em±	0.02	0.1	0.11	0.4	0.1	0.3	0.3	0.02
CD(P=0.05)	0.07	0.2	NS	1.1	0.2	0.8	1.0	0.10
Interaction (V×P)								
S Em±	0.06	0.2	0.27	0.9	0.1	0.7	0.9	0.05
CD(P=0.05)	0.17	NS	NS	2.6	NS	NS	2.5	0.10

CP-Crude protein CPY-Crude protein yield TSS- Total soluble sugars; ADF-Acid detergent fiber NDF-Neutral detergent fiber

CONCLUSIONS

Based on the research results of the present study it can be concluded that, fodder maize variety J-1006 recorded significantly superior quality parameters like higher lactic acid concentration (3.2%), crude protein (5.6%), optimum ADF (44.3%), NDF (63.7%) and desirable pH (3.9) ensiled at milky stage of harvest.

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