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IMPACT OF MATURITY AND VARIETY ON NUTRITIVE VALUE AND IN SITU DIGESTION KINETICS OF MAIZE (*ZEA MAYS*) IN NILI RAVI BUFFALO BULLS

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Abstract

The study aimed to evaluate the nutritive profile and the in situ digestion kinetics of three maize forage varieties (Sadaf, Sultan and Sadaf white) harvested at 35 and 60 days of age following the completely randomized experimental design with 3x2 factorial arrangements of the treatments. After the harvesting of fodder was chopped and the experimental samples were dried in hot air oven and ground to 2mm size in a Willey mill. Samples were examined for (DM, CP, NDF, ADF, ADL, cellulose and hemi cellulose) contents by standard procedures. The in situ digestion kinetics of three maize forage varieties for DM and NDF was performed in three Nili-Ravi bulls fitted with fistula. The bags were subjected to fermentation in the rumen for 0, 2, 4, 6, 12, 24, 36, 48, 72 and 96 hours. Upon removing from the rumen, the contents in the bags were subjected to analysis for proximate & fiber composition. Dry matter and NDF digestibility, rate and extent of DM and NDF disappearance decreased as maize fodder matured. The in situ DM and NDF disappearance was similar for all the varieties, but it was decreased with the plant being more mature. The early harvested varieties of the fodder had a shorter (P<0.05) lag time for DM and NDF than the later ones.

Keywords: *Buffalo, Digestion kinetics, Digestibility, Dry matter, Maize forages*

INTRODUCTION

The importance of fodder crops in livestock production needs no more emphasis because forages are a major source of livestock feed (1). It is expected that ruminants will much rely on forages because of eagerly growing world human population, having a straight competition with livestock for basic food grains; hence forages will remain a major fraction of ruminant's diet (2).

Further, these unique animals needs crude protein, energy (in the form of fiber), fat, vitamins and minerals to fulfill body needs, however, a lack of focus on these principal dietary ingredients leads to sub optimal performance (3). Among the south Asian countries Pakistan is holding very huge population of livestock i.e. 181.2 million heads growing at unchecked average rate and facing a serious problem of inadequate fodder both in term of quantity and quality (4).

Although fodders like Oats, maize, sada bahar, sorghum, cowpeas, guar, mott grass, lucerne, berseem mustard and turnip are being grown but current quantity produced fodder seems unable to full the requirement and exploit production potential of native breeds. The factors like limited input resources, poor agronomic practices and low productive potential of fodder varieties further aggravate the situation. So it is need of time to explore new local fodder varieties with low input cost which may serve the purpose successfully (1).

Among local fodders of Pakistan, maize (*Zea mays*) is a vital non-leguminous thirds cereal crop cultivated on an area of about 1413 thousand hectares with a total production of 7,276 thousand tones (5). Globally this unique crop is used as staple food and plays a remarkable role in fulfilling the nutrient requirement of feedlots. The production yield of maize fodder is greatly influenced by a variety of factors such as the sown variety, environmental conditions as well as soil conditions (6). Further, analysis by (7, 8) highlights that crop harvesting- period physiological maturity may modulate its physical and chemical stricture. Moreover, different varieties of the same fodder may also differ in their nutritive value (9). So, its utilization may be improved by considering the factors such as harvesting at milking stage with a low lignin, optimum DM value and selection of an appropriate fodder variety as feed (10).

As data is still lacking on the concern; hence, the present study was designed to find out the nutritive worth of various Maize varieties harvested at various maturity stages and also to calculate them *in situ* digestion kinetics in the buffalo bulls of Nili Ravi breed.

MATERIALS AND METHODS

This trial was executed at Raja Muhammad Akram Animal Nutrition Research Center, University of Agriculture Faisalabad, Pakistan. Three rumen fistulated *Nili Ravi* buffalo bulls of almost same weight and age were selected to access the nutritive value and *in situ* digestion kinetics of three maizes (*Zea Mays*) fodder varieties i.e. Sadaf, Golden and Sadaf white which were harvested at 35 and 60 days of age. During the trial bulls were offered the same diet which was under their ruminal incubation for avoiding the effect of diet on the fermentation pattern of the rumen. During experimental period there was an access of clean and safe drinking water to bulls. The total time for the trial was 14 days in which 10 days were considered as adjustment period following a 4-day incubation period for each variety.

The experimental maize varieties were chopped and oven dried (55 ° C). Later the samples particles were made 2mm screen in a Wiley mill. The analysis of the maize fodder varieties was performed for dry matter (DM), crude protein (CP), ether extract (EE) (11); whilst the fibrous portion such as neutral Detergent Fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) (12). The samples of each maize variety (10 g DM basis) were filled in nylon bags (10 cm × 23 cm, pore size 50 µm) and incubated in the rumen of buffalo bulls for a duration of 0, 2, 4, 6, 12, 24, 36, 48, 72 and 96 hours.

For each point of time/duration, every sample had three bags. The 2 bags were utilized for determining the DM and NDF digestion; while the 3rd was kept as blank one (13). Samples of each variety were separately incubated in selected buffalo bull. Each variety was harvested at two stages of maturity and each treatment had four replicates while the fifth was kept blank for each time point. In this way for each time point there were 10 bags incubated in the rumen of each buffalo bull (total 100 bags were incubated in one bull). Soaking of the Bags for 15 minutes was done in the distilled water (39 °C) just before exposing them to the rumen (14). The arrangements of placement of bags in the rumen of buffalo bulls were sequenced in reverse order and they were removed simultaneously to reduce the variation due to procedure of washing (15). Upon removal of the bags from the rumen, they were washed and rinsed clear with running tap water. After that these bags were dried at a temperature of 55 °C in a forced air oven. After the equilibration, the weight of the bags was recorded and the transfer of the residues was made to 100 ml

beakers for NDF determination. The Digestion coefficient of DM and NDF was calculated at 48 hours of incubating. The lag time, extent of digestion and the rate of disappearance of DM and NDF for the varieties of maize varieties harvested at different maturity stages were according to the methodology of (16).

STATISTICAL ANALYSIS

The collected data for lag time rate and extent of digestion was analyzed 2x3 factorial arrangements of treatments using Completely Randomized Design (CRD). The ($P<0.05$) difference among the means were compared using Duncan's Multiple Range (DMR) test (17). The statistical model utilized for all the parameters was:

$$Y_{ijk} = \mu + \alpha_j + \beta_k + (\alpha\beta)_{jk} + \varepsilon_{ijk}$$

The above equation describes that μ is the mean of all the observations, α_j was the outcome of varieties (three maize varieties), β_k was the effect of harvest date (on 35 and 60 days maturity), $(\alpha\beta)_{jk}$ interactions between factors A and B while, ε_{ijk} was the difference within treatment means (variable error term).

RESULTS AND DISCUSSION

CHEMICAL COMPOSITION

This study was executed to evaluate the principal chemical profile of three specific maize verities collected at physiological stage of 35 and 60 days' post-maturity, as illustrated Table 1. After the analysis we found that ratio of crude protein contents decreased whilst the cell wall contents viz: NDF, ADF, ADL, hemicelluloses, cellulose and DM ratio increased with the increased harvesting time.

This increase in fiber fractions and reduction in CP contents with advancing maturity was attributed to the decrease in leaf to stem ratio as well as the rate of accumulation of structural materials (18). Harvesting at an early age may improve forage quality. Our findings corroborate with the findings of (19) who noted a higher Cell wall contents i.e. NDF and ADF with later stage harvesting of three maize hybrid cultivars. Moreover, the author added that this may be associated with the lower leave to stem ratio in plant. A decline in the cell soluble material was found whilst the NDF and other fibrous parameters increased in winter wheat hay cultivars linked to late harvesting (20). The results are also in accordance with (21). A increase of 6 and 7.5% in the NDF and ADF contents were found during the chemical composition study of grasses on the varying growth intervals (22). Apart from cutting the hybrid also impact nutritive value of plant (23). A reduced CP contents ($P>0.05$) and increased ($P<0.05$) NDF contents were found in the maize harvested at 65 days of sowing relative to 45 and showed low organic values (24). Similar to our findings, (25) also found a low CP contents 13 to 10.5% and NDF increased from 40 to 65%, ryegrass (*Lolium multiflorum*) with the advancement of growing season Numerically, the maize silage cutting at a height of 20.3 cm has 9.2% of greater NDF and same percentage i.e., 9.2% of lesser starch than maize silage cutting at a height of 61cm. The larger quantity of starch in the silage made from higher cutting may affect digestibility considerably. Although starch seems to be more digestible than fiber, however, when large amounts of starch was included in the diets, there is a depression in the NDF digestibility (26, 27) caused by the increase in production of ruminal organic acids.

Table I. Chemical composition (%) of maize verities

Parameters	Sultan		Sadaf		Sadaf White	
	35 days	60 days	35 days	60 days	35 days	60 days
Dry Matter	19.5	27.8	18.6	28.5	19.0	27.9
Crude Protein	8.5	6.1	8.1	6.0	8.6	6.6
Neutral Detergent Fiber	68.5	76.1	68.9	75.5	67.4	74.3
Acid Detergent Fiber	43.3	49.8	42.1	49.2	42.5	48.1
Acid Detergent Lignin	6.9	8.9	7.3	9.1	6.8	9.4
Cellulose	36.5	38.9	34.8	40.1	35.7	38.7
Hemicellulose	25.1	26.3	26.8	26.8	24.9	26.2

IN SITU DM AND NDF DEGRADABILITY

The Table II illustrates the percentage of *in situ* Dry matter degradability (DMD) of Maize fodder. The values for DMD of varieties i.e. Sultan, Sadaf and Sadaf white were found to be 57.05, 57.07 and 57.0% on 60 days after harvesting relative to the 35 days harvesting 69.0, 69.11 and 69.07% at 48 hours' incubation period. These values indicate that there was a declining trend of DMD with plant maturity. The stage of harvest had a significant (P<0.05) effect in terms of DMD while the impact of maize varieties (Sultan, Sadaf and Sadaf white) were found to be alike in present research.

Apart from this rate and extent of DMD among all the varieties in question remained statistically unchanged (P>0.05). In our study these parameters were affected (P<0.05) by stage of cutting. The lag time (hour) exhibited reverse order as was found in rate of degradation for all the treatments. The *in situ* Neutral Detergent Fiber degradability (NDFD) during 48 hours of incubation of different varieties of maize were significantly lower in fodder harvested at 60 days of maturity relative to the maize harvested at 35 days' period (P<0.05). Moreover, the current study also highlighted that extent and rate of NDFD remained similar among all the cultivars. The lag time (hour) of NDF exhibited reverse tendency as was found in the rate and extent of NDF degradation for all treatments. Nevertheless, all the cultivars remained statistically unchanged regarding the aforesaid parameters. Reports indicate that lower cell soluble contents and higher cell contents in the fodder may depress the NDFD and that is associated with the plant later stage harvesting and feeding (28). Further the *in vivo* and *in vitro* various results indicate that the DM digestibility is negatively affected by high lignin contents and this might be associated with higher structural plant carbohydrate. The depression in the disappearance rate with increased forage fiber (NDF, ADF) associated with carbohydrate moieties and lignin. This is ubiquitously recognized that ruminal microorganisms much easily consume cell soluble matter compared to fiber. Reports indicate that rise in ADL level in plant directly correlate with plant increased maturity, hence this phenomenon may reduce the rate of NDF disappearance and this is similar to our conclusion (7). Further, Vanhatalo et al., (2009) also noted a higher rate of DM digestion in legume silages harvested on early age as compared to later harvested (29).

Moreover, it had been noted that later harvesting of fodder/forage impacts DM digestibility might affect the ruminal environment as well as early and late harvest of maize (8). Same as above, Hoffman et al., (2003) found that the digestibility of NDF may significantly be affected by crop maturity however the decline may depend on forage type (30). Secondly the NDF digestibility is also affected by leaf to stem ratio (more stem, fewer leaves). As the plant ages it goes to certain physiological stages (develop xylem) and lignifies the plant cell which consequently makes more bacterial attachment to the plant.

Table II. Comparative in situ Dry Matter and Neutral Detergent Fiber Digestion Kinetics of different varieties of maize harvested at 35 and 60 days of maturity

Parameters	Sultan		Sadaf White		Sadaf		SE	Main Effects		Interaction
	35 days	60 days	35 days	60 days	35 days	60 days		A	B	
Dry Matter Digestibility[1],%	69.00[a]	57.05[b]	69.11[a]	57.07[b]	69.07[a]	57.00[b]	0.33	NS	**	NS
Rate of degradation, % hour-[1]	4.50[a]	3.05[b]	4.56[a]	3.10[b]	4.62[a]	3.15[b]	0.17	NS	**	NS
Lag, hour	1.57[b]	3.20[a]	1.59[b]	3.20[a]	1.60[b]	3.10[a]	0.19	NS	**	NS
Extent[2], %	74.00[a]	72.40[b]	73.80[ab]	74.05[a]	70.72[b]	64.40[c]	0.70	NS	**	NS
Neutral Detergent Fiber Digestibility[1]	61.40[a]	52.10[b]	60.01[a]	52.70[b]	60.10[a]	51.90[b]	0.63	NS	**	NS
Rate of degradation, % hour-[1]	4.10[a]	2.60[b]	4.12[a]	2.58[b]	4.10[a]	2.69[b]	0.26	NS	**	NS
Lag, hour	1.90[b]	3.58[a]	1.89[b]	3.60[a]	1.90[b]	3.60[a]	0.23	NS	**	NS
Extent[2], %	71.10[a]	61.80[b]	72.00[a]	62.60[b]	71.50[a]	61.80[b]	0.53	NS	**	NS

Means within same row bearing different superscripts are significantly different (P<0.05)

[1]Degradability was determined at forty-eight hours of incubation;

[2]Extent of digestion was determined at ninety-six hours of incubation

CONCLUSION

The corn varieties harvested at the age of thirty-five days had higher crude protein contents and showed better *in situ* DM and NDF digestion kinetics in *Nili-Ravi* buffaloes.

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