Ethiop. J. Appl. Sci. Technol. 2(2): 87-91 (2011)

SHORT COMMUNICATION

Effect of variety of maize on yield of grain, residue fractions and the nutritive value of the whole stover

Diriba Geleti[1*], Adugna Tolera[2], Ashenafi Mengistu[3] and Mekonnen Hailemariam[3]

[1] Ethiopian Institute of Agricultural Research, Debre Zeit Research Centre
[2]Department of Animal and Range Sciences, Hawassa University
[3]School of Veterinary Medicine, Addis Ababa University
*Corresponding Author: dgeleti2005@yahoo.com

(Received in revised form: December 27, 2011)

ABSTRACT

The study was conducted with the aim of evaluating three maize varieties (BH-660, BH-540 and Kulani) all released for production in high potential maize zones of Ethiopia by Bako Research Center for grain yield, stover components, digestible crop residue yield and nutritive value of the stover. The analysis of variance revealed that differences between varieties were significant (P<0.01) for all measured parameters except for the husk fraction (P>0.05); grain and leaf yields being significantly highest for BH-660. The cob and total residue yields were lowest for BH-540. The values for harvest index were highest for BH-540 (52.74%), intermediate for BH-660 (51.96 %) and lowest for Kulani (45.66 %). Significant varietal differences were observed for ash (P<0.01), neutral detergent fibre (P<0.01), acid detergent fibre (P<0.05), acid detergent lignin (P<0.05) and *in vitro* DM digestibility (P<0.01) values. The present study generally revealed that BH-660 and BH-540 had higher grain yield compared to the variety Kulani. Ranking of the varieties was consistent for harvest index, potential utility index and digestible crop residue yield, the order being BH-540 > BH-660 > Kulani. Consistently similar ranking order was observed for stalk, total residue, CP and CP yield; the ranking being Kulani > BH- 660 > BH-540. BH-660 ranked first in grain yield and consistently ranked second for most of the important quality traits. Varieties with higher grain yield were also observed to have higher digestible crop residue yields suggesting the possibility of selecting maize varieties that combine grain yield with desirable residue quality attributes.

Keywords: Maize Variety; Nutritive value; grain yield; stover; chemical composition; *in vitro* DM digestibility

INTRODUCTION

Maize ranks first in production and yield among main cereals in Ethiopia (Benti *et al.,* 1992). The improvement efforts made so far focused on grain yield and no attention has been given to yield and quality of the stover (Adugna *et al.*, 1999). In maize dominated farming system of Western Ethiopia, farmers traditionally use maize stover as important source of feed, firewood and construction of grain storage structures. Due to rapidly increasing human population and a subsequent need for cultivable land, more grazing land is being put under cereal production mainly maize in sub humid climatic conditions of Ethiopia. It is, therefore, important to have a high grain and quality stover yielding varieties to improve animal feed availability in the maize based systems.

Literature evidences reveal the existence of genetic differences in yield and quality of cereal residues. Pearce *et al.* (1988) for example have reported wide genotypic differences for leaf to stem ratio, chemical components, *in vitro* DM digestibility and intake for rice. Saini *et al.* (1977) reported that digestibility, neutral detergent fiber and tannin contents are under genetic control in sorghum, and consequently improvements through breeding should be possible. Moreover, Rattunde (1998) detected large genetic variation for grain and stover yields in sorghum, with these attributes not

negatively correlated. Studies conducted by Adugna *et al.* (1999) have also revealed evidence of varietal differences in grain and stover yields; and stover quality in maize and suggested that there are possibilities of selecting for maize varieties that combine high grain yield and desirable stover quality parameters. This suggests that there are considerable opportunities for selection favoring both traits provided that plant breeders, agronomists and animal nutritionists make joint efforts. The objective of the present study was to evaluate three commonly grown maize varieties for grain and digestible crop residue yield and nutritive value of the stover.

MATERIALS AND METHODS

Experimental site

The study was carried out at Bako Agricultural Research Center located at $09^0 6'$ latitude, $37^0 09'$ E longitude and 1650 m.a.s.l. The mean annual rainfall is 1200 mm, of which more than 80 percent is received between May and September. The mean minimum and maximum temperatures of the area are 13.7 and 27.9^{0}C, respectively. The soil is reddish-brown clay to sandy-clay loam Nitosols with a pH ranging from 5.3-6.

Maize varieties and crop management practices

Three maize varieties (BH-660, BH-540 and Kulani) developed by Bako Agricultural Research Center, Ethiopia were used for the study. BH-660 adapts well in areas having an altitude ranging from 1600-2400 and BH-540 was released for areas having an altitude varying from 1000-2000 masl. Kulani adapts well to areas with an altitude range of 1700-2400 masl. BH-660, BH-540 and Kulani were grown on neighboring plots at the Animal Feeds and Nutrition Division Research Farm of Bako Agricultural Research Center on 1,298, 930 and 525m^2 areas, respectively. An intra- and inter-row spacing of 50 and 80 cm, respectively, and recommended fertilizer rate of 92/69 N/P_2O_5/ha was used for BH-660. For BH-540 and Kulani, the within and between row spacing was 25 and 75cm, respectively, and the fertilizer rate used was 75/75 N/P_2O_5/ha. All field operations were done as per the available recommendations for maize production. At grain maturity 10 samples of 8, 6 and 6-m^2 area for BH-660, BH-540 and Kulani, respectively were harvested by cutting the stalk at about 10 cm above ground level. The harvested stover was partitioned in to grain and different stover components. Sub samples of each stover component were dried in an oven at 65 ^{0}C for 72 hrs to determine the dry matter yield for each component. Harvest index (HI) was calculated as the ratio of grain to total above ground biomass yield multiplied by 100. The potential utility index (PUI) of the different maize varieties was calculated according to Fleischer *et al.* (1989):

PUI = (Grain yield + Digestible crop residue DM yield)/ (Total aboveground biomass DM yield) × 100

Samples were arranged in completely randomized block design considering the 10 randomly collected samples of each variety as replicates for both yield and stover quality attributes. The *in vitro* DM degradability was used to calculate digestible crop residue DM yield. Digestible crop residue yield (DCRY) was calculated by multiplying the *in vitro* DM values by the whole residue DM yields and crude protein (CP) yield was also estimated by multiplying crude protein concentration of the whole stover by the total crop residue DM yield.

Chemical composition and *in vitro* DM digestibility

DM and ash contents were determined according to the procedure of AOAC (1980). The concentration of N was determined by micro Kjeldhal procedure and CP content was calculated as N x 6.25. The neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Goering and Van Soest (1970) and a modified *in vitro* Tilley and Terry technique (1963) was used to determine *in vitro* DM digestibility (IVDMD).

Data analysis

Data were analyzed by using Microsoft Excel 2003 (Microsoft Corp) and SAS, 2002 computer software Programs. The analysis of variance was conducted using GLM procedure (SAS, 2002) and significant mean differences were detected using the least significant difference (LSD) procedure.

RESULTS AND DISCUSSION

Grain yield, yield components and indices

The mean grain yield and other components, harvest and potential utility indices, digestible crop residue and crude protein yields of the three maize varieties are given in Table 1. Varietal differences were significant ($P<0.01$) for all measured parameters except for the husk fractions ($P>0.05$). Grain and leaf yields were significantly highest for BH-660. The cob and total residue yields were lowest for BH-540 and in most cases values with a narrow range of differences were observed for BH-660 and Kulani.

Ethiop. J. Appl. Sci. Technol. 2(2): 87-91 (2011)

The values for harvest index were highest for BH-540 (52.74%), intermediate for BH-660 (51.96 %) and lowest for Kulani (45.66 %). Harvest index for Kulani in the present study is similar to indices reported for open pollinated varieties by Adugna *et al.* (1999). Narrow inter-varietal differences for harvest index were observed in the current study for the hybrid varieties, BH-660 and BH-540, and the values are generally higher when compared with the open pollinated variety.

Table 1. Effect of variety on maize grain yield, yield components, harvest and potential utility indices, crude protein and digestible crop residue yields of three maize varieties (n = 10)

Traits measured	Maize varieties		
	Kulani	BH-660	BH-540
Grain (t ha^{-1})	7.86±0.19b[#]	9.93±0.19a	8.0±0.19 b
Stover fractions and total stover yield (t ha^{-1})			
Cob	1.66±0.07a	1.59±0.07a	1.28±0.07b
Stalk	4.05±0.24a	3.62±0.24a	2.56±0.24b
Leaf	2.36±0.13b	2.93±0.13a	2.09±0.13b
Husk	1.32±0.06	1.09±0.06	1.19±0.06
Total residue	9.37±0.36a	9.24±0.36a	7.17±0.36b
Harvest and potential utility indices (%)			
Harvest index	45.66±0.97b	51.96±0.97a	52.74±0.97a
Potential utility index	67.51±1.43b	71.61±1.43b	78.18±1.43a
Digestible crop residue (t $^{ha-1}$) and crude protein (Kg $^{ha-1}$) yields			
Digestible crop residue yield	3.77±0.29ab	3.75±0.29b	3.86±0.29a
Crude protein yield	261.0±15.33a	254.0±15.33a	195.0±15.33b

[#]Means within rows followed by different letters vary significantly (P<0.01)

Digestible crop residue yield was higher for BH-540 followed by Kulani and BH-660. The crude protein yield was significantly lower for BH-540, intermediate for BH-660 and higher for Kulani. The significant differences in potential utility index (PUI) in the present study is also in agreement with results reported elsewhere (Adugna *et el.*, 1999). The mean percentage values of potential utility indices for all varieties were also higher than those of the harvest indices indicating the higher potential benefit of maize if residues are effectively utilized for animal.

Chemical composition and *in vitro* DM digestibility of crop residues

The effect of variety on chemical composition and *in vitro* DM digestibility of the crop residues of three maize varieties is shown in Table 2. Significant varietal effects were observed for ash (P<0.01), NDF (P<0.01), ADF (P<0.05), ADL (P<0.05) and IVDMD (P<0.01) values. For N and ADF-ash, the effect of variety was not significant (P>0.05). The significant varietal difference for ash and other fiber components in the current study is in agreement with the reports of Adugna *et al*. (1999) who found significant (P<0.05) varietal differences for these components in maize.

Table 2. Effect of variety on ash (%DM), crude protein (% DM), and fiber components (g/kg) and *in vitro* DMD (%DM) of three maize (n=10) Varieties

Variables	Varieties		
	Kulani	BH-660	BH-540
DM	90.03±0.31	89.78±0.31	89.80±0.31
Ash	4.33±0.26b[#]	4.43±0.26b	5.55±0.26a
CP	2.79±0.23	2.78±0.23	2.71±0.23
NDF	741.30±8.46b	772.45±8.46b	867.20±8.46a
ADF	442.27±6.35b	458.41±6.35ab	463.91±6.35a
ADL	44.69±2.21b	52.57±2.21a	47.86±2.21ab
IVDMD	40.20±1.35b	44.78±1.35b	53.86±1.35a

[#]Means within row followed by different letters vary significantly (P<0.01 for ash, NDF and IVDMD; and P<0.05 for ADF and ADL)

The overall mean in ash concentration obtained in the present study (4.334g/kg), however, is much lower than the mean values reported previously (74g/kg) by Adugna *et al.* (1999). The significant difference for *in vitro* DM digestibility among varieties observed in this study is contrary to the reports made by Fleischer *et al.* (1989) for maize. Adugna *et al*. (1999) also reported a significant difference in *in sacco* DM digestibility of various maize varieties. In general, the CP values of all varieties in the present study were lower than the critical level of 8 percent suggested by Milford and Haydock (1965). It can thus be implied that intake and utilization of these residues would be low unless supplemented with a protein–rich diet. Adugna *et al.* (1999), in evaluating different maize varieties have suggested that due to low CP and high lignocellulosic cell wall contents, it is justifiable to evaluate alternative sources of protein if nutritional constraints to animal production is to be alleviated. In conclusion, the present study revealed that the hybrids, BH-660 and BH-540, had higher grain yield compared to the open pollinated variety, Kulani. Ranking of varieties was consistent for harvest index, potential utility index and digestible crop residue yield, the order being BH-540 > BH-660 > Kulani. The same was also true for ranking varieties using NDF, ADF and IVDMD. Consistently, similar ranking order of the varieties was observed for stalk, total residue, CP and CP yield; the ranking order being Kulani > BH- 660 > BH-540. The hybrid, BH-660 ranked first in grain yield and consistently ranked second for most of the important quality traits suggesting the possibility of selecting for varieties that combine higher grain yield with desirable quality parameters.

ACKNOWLEDGEMENTS

The field implementation of the study was financially supported by the regional state of Oromia. We also would like to thank the technical staff of the Animal Feeds and Nutrition Division of Bako Research Centre for their support in field management and data collection.

Ethiop. J. Appl. Sci. Technol. 2(2): 87-91 (2011)

REFERENCES

AOAC. 1980. Association of Official Analytical chemists. Official Methods of Analysis, Arlington, UA, USA.

Adugna Tolera, Trygve Berg and Sundstol, F. 1999. The effect of variety on maize grain and crop residue yield and nutritive value of the stover. Animal feed Science and Technology,79: 165-177.

Fleischer, JE., Barnes, AR. And Awubila, B. 1989. Grain yield and nutritive value of crop residues from three varieties of maize (Zea mays L.) crop. In: Said, A. N., Dzowela, B. H. (eds.), Overcoming constraints to Efficient Utilization of Agricultural By-products as Animal Feed. Proc. Fourth Annual workshop held at the Institute of Animal Research, Mankon station, Bamenda, Cameroon, 20-27 Oct. 1987, African Research Network for Agricultural By-products 9ARNAB), Addis Abeba, Ethiopia, pp. 239-255.

Goering, HK. and Van Soest, PJ. 1970. Forage Fiber Analysis (Apparatus, Reagents, Procedures and some applications). Agricultural Handbook No. 379, USDA, Washington, DC, USA.

Kush, GS., Juliano, BO. and Roxas, DB. 1988. Genetic selection for improved nutritional quality of rice straw a plant breeder's viewpoint. In: Reed, J.D., Capper, B.S. and Neate, P.J.H. (eds). Plant breeding and the nutritive value of crop residues. Proceedings, workshop. ILCA, Addis Abeba, 7-10 December 1987.

Milford, R. and Haydock KP. 1965. The nutritive value of protein in subtropical pasture species grown in Southeast Queensland. Aust. J. Exp. Agric. Anim. Husb. 5: 13 - 17.

Pearce, GR., Lee, JA., Simpson, RJ. and Doyle, PT. 1988. Sources of variation in the nutritive value of wheat and rice straws. In: Reed, J.D., Capper, B.S. and Neate, P.J.H. (eds.). Plant breeding and the nutritive value of crop residues. Proceedings, workshop. ILCA, Addis Abeba, 7-10 December 1987.

Rattunde, HFW. 1998. Early maturing dual-purpose sorghums: Agronomic trait variation and co variation among landraces. Plant Breeding. 117: 33-36.

Saini, ML., Paroda, RS. and Arora, SK. 1977. Interspecific hybridization in sorghums for improvement in forage yield and quality. Indian Journal of Genetics and Plant Breeding. 37: 218-224.

SAS. 2002. Statistical Analysis System Institute Inc., Cary, NC, USA.

Tilley, JMA. and Terry, RA. 1963. A two-stage technique for in vitro digestion of forage crops. J. British Grassland Society, 18: 104-111.