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Evaluation of normal and specialty corn for fodder yield and quality traits

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Abstract

To evaluate fodder potentiality of different types of maize, five maize genotypes grown under different use pattern such as baby corn (HM-4), sweet corn (HSC-1), forage type maize (J-1006), normal maize (DHM-117) and quality protein maize (HQPM-5) were analyzed for forage quality. Study indicated that forage maize exhibited highest crude protein (CP) with higher *in-vitro* dry matter digestibility (IVDMD) and lowest values of dry matter, ADF and ADL content. The baby corn hybrid (HM-4) was found almost at par to fodder maize in terms of forage quality parameters entailing its use as animal fodder. Forage quality of DHM-117 (normal maize) and HQPM-5 was also found comparable to fodder maize. Nutritional quality of silage made of sweet corn variety (HSC-1) was found to be better as compared to its green fodder. However, small loss of nutrients was observed in silage as compared to green forage, but it significantly improved its digestibility. The correlation data showed that CP was positively related to IVDMD but negatively associated with fiber components (CF, NDF and ADF). The study concluded that specialty maize possess the required characteristics of a nutritious fodder and its preservation as silage could significantly minimize the green fodder deficit in India.

Keywords: Baby corn, Forage maize, Forage quality, Silage, Sweet corn

Abbreviations: ADF: Acid detergent fiber; **ADL:** Acid detergent lignin; **CF:** Crude fiber; **CP:** Crude protein; **DA:** Days to anthesis; **DM:** Dry matter; **DS:** Days to silking; **GFY/p:** Green fodder yield per plant; **IVDM:** *In vitro* dry matter digestibility; **LL:** leaf length; **LW:** leaf width; **NDF:** Neutral detergent fiber; **NL:** number of leaves; **PH:** Plant height; **TA:** Total ash

Introduction

The diversified use of maize crop is gaining demand as grain, animal feed and fodder and other industrial uses. This crop plays a very important role in human and animal nutrition. It is cultivated in about 160 countries having wider diversity of soil, climate, biodiversity and management practices and contributes around 36% to global grain production. The global maize (corn) production during 2013-14 was 967 million tons (mt) from an area of about 177 million hectares (mha). USA, China, Brazil, Mexico, Argentina, Indonesia, India, France, South Africa and Ukraine are the top ten maize producing countries in the world (FAOSTAT, 2012). In India, maize is the third most important food crop after rice and wheat. Its production has reached 25 million tons, out of which 25% is used as human food, 49% as poultry feed, 12% as animal feed, remaining used as industrial raw material and other purposes (Rani *et al*., 2015). In addition to the above, maize plant is also used as animal fodder for livestock throughout the world. It is considered ideal forage because it grows quickly, produces high palatable biomass, and helps to increase body weights and milk quality in cattle due to higher nutritional value (Sattar *et al*., 1994; Hukkeri *et al*., 1977; Iqbal *et al*., 2006). Indeed, green fodders are considered as backbone of dairy sector and round the year availability of green fodder is the major concern in developing a sustainable dairy farming (Naik *et al*., 2012). However, the scarcity of green fodder is severe and at present, India alone faces a net deficit of 61.1% green fodder, 21.9% dry crop residues and 64% concentrate feeds. The ever increasing cultivation of cereals and cash crops resulted in shrinking the land for fodder cultivation which is the major constraints in improving green fodders production. The increasing cultivation of specialty corns such as sweet corn and baby corn in the peri - urban regions of the country provided a much needed respite in reducing the demand and supply gap of fodder. Due to increasing cultivation of baby corn and sweet corn, a lot of green maize stalk is available which is used as animal fodder. Thus apart from furnishing the nutritional needs of the mankind, maize could also contribute to fulfill the nutritional requirement of livestock. Keeping these in view, different types of maize grown under different use pattern were evaluated for important fodder quality traits.

Materials and Methods

***Experimental design and sample analysis*: **Five different categories of maize hybrids/composite *viz*., HM-4 (baby corn, HKI-1105 x HKI-323), DHM-117 (normal corn, BML-6 x BML-7), J-1006 (fodder maize, composite, makki safed-1 x tuxpeno planta baja CL), HQPM-5 (QPM, HKI_163 x HKI-161), HSC-1 (sweet corn, HKI-1831 x SCST) were grown in the experimental area of Regional Research Station and seed production centre, Begusarai, Bihar during *kharif* 2012. The experiment was laid out under RBD with 6 replications. Each type of corn was grown in an area of 150 m^2. To raise healthy crop recommended agronomic practices were followed.

The baby corn starts emerging at about 45 days after sowing. The emergent baby cobs were harvested till its emergence ceases. At this stage, the genotypes grown for baby corn (HM-4), forage type maize (J-1006), normal maize (DHM-117) and quality protein maize (HQPM-5) are harvested for green fodder. Around one kg of representative sample was collected for forage quality analysis and the remaining biomass was preserved as silage in individual silo pit of capacity 3×3×1.5 feet. Similarly, the genotype HSC-1 was harvested at about 70 days after sowing till there is no further emergence of sweet corns and subsequently the samples were collected for forage quality analysis and preserved as silage in silo pit as described above. Samples, taken from each plot, were dried in shade followed by overnight drying in hot air oven at 80°C for dry matter estimation. The silo pits were opened after a period of 45 days and the silage sample taken from each pit were dried in hot air oven at 80°C overnight for dry matter estimation. Dried samples were ground in Willey mill grinder using 2 mm sieve and were used for proximate and cell wall analysis and *in-vitro* dry matter digestibility (IVDMD). The proximate analysis of nutrients was carried out as per the AOAC (1995) and the cell wall constituents were determined by the method of Goering and Van Soest (1970). The IVDMD was estimated following the method of Tilley and Terry (1963).

Statistical analysis: Data was subjected to descriptive statistics and analysis of variance (ANOVA) was conducted using SPSS 14.0 Software. Pearson's simple correlation coefficient between different biochemical parameters were computed using mean values. The difference between green forage and silage was computed using student's t-test.

Results and Discussion

Morphological variation: Large variation in relation to morphological traits was observed in different types of maize. HSC-1 was earliest in days to silking as compared to other maize types. The GFY was significantly higher in J-1006 and HQPM-5, whereas it was lowest in HSC-1. The fodder and QPM maize variety produced higher biomass (Table 1).

Quality traits of green fodder and silage: Dry matter is an important component pertaining to nutritional quality of given forage. It keeps on increasing with advancing maturity, whereas forage quality declines with age (Blaser *et al*., 1986; Fick *et al*., 1994). Maturity at harvest also influences preferential consumption of forage by animals. As plants matures and become more fibrous, forage intake drops dramatically due to greater amounts of cell wall structural components such as lignin which results in dilution of energy, protein and other nutrients in addition to decline in nutrient digestibility (Jung and Allen, 1995). Fodder maize (J-1006) exhibited lowest dry matter (DM) content followed by DHM-117 (normal maize), HM-4 (baby corn), HQPM-5; whereas the sweet corn variety (HSC-1) recorded significantly higher dry matter as compared to other genotypes. Higher dry matter concentrations observed in sweet corn, therefore, was due to its advanced stage of maturity at harvest. Fodder maize (J-1006) had characteristic of tall plants having broad leaves and thin stems (Gupta *et al*., 2004) which might have contributed towards its lower dry matter content. The color of the silage was found to be bright light green with a pH less than 4 in all the samples, indicating its excellent fermentation during preservation process. Dry matter in silage was found to be reduced as compared to green fodder, significant reduction being observed in DHM-117 (Table 2). An average loss of 8% was observed in dry matter of maize silage (Kohler *et al*., 2013).Wilting, fermentation, respiration and reheating were considered to be the major sources of dry matter losses in silage (Spiekers *et al*., 2009).

Table 1. Morphological variation in normal and specialty corn

Varieties	Days to anthesis	Days to silking	Plant height (cm)	No. of leaves/plant	Leaf length	Leaf width	GFY/plant (g)
HM-4	56	58	181.35	12.15	78.43	8.94	197.76
DHM-117	55	57	189.36	14.51	86.01	8.15	265.97
J-1006	61	64	263.15	14.65	89.93	10.35	394.24
HQPM-5	56	57	204.65	12.25	81.99	8.84	342.14
HSC-1	50	52	183.21	12.98	81.49	7.95	190.17
Mean	55.6	57.6	202.66	12.87	83.4	8.45	278.56
CD (P<0.05)	2.74	2.91	19.24	0.48	2.88	0.51	39.95
CV (%)	3.21	4.36	13.68	1.22	8.65	2.14	15.65

Table 2. Paired t-test for comparison of quality traits of fodder and silage

Varieties	DM			CP			CF			TA		
	Fodder	Silage	p(t test)	Fodder	Silage	p(t test)	Fodder	Silage	p(t test)	Fodder	Silage	p(t test)
HM-4	26.50	25.20	0.10	9.34	9.15	0.28	32.75	30.90	0.12	4.96	4.90	0.05*
DHM-117	23.80	22.30	0.04*	7.72	6.25	0.11	31.85	31.75	0.87	6.90	7.00	0.70
J-1006	23.00	22.00	0.30	9.63	8.00	0.11	30.00	27.80	0.20	6.10	6.30	0.50
HQPM-5	27.60	23.05	0.12	7.73	7.50	0.42	33.10	31.00	0.05*	4.79	4.81	0.76
HSC-1	37.50	35.45	0.08	6.45	6.10	0.50	40.50	36.00	0.10	5.19	5.24	0.68
			0.001			0.008			0.002			0.284

Varieties	IVDMD			NDF			ADF			ADL		
	Fodder	Silage	p(t test)	Fodder	Silage	p(t test)	Fodder	Silage	p(t test)	Fodder	Silage	p(t test)
HM-4	58.50	59.70	0.11	72.50	69.95	0.05*	45.60	42.40	0.08	4.95	4.75	0.50
DHM-117	63.20	65.85	0.04*	70.40	67.35	0.15	41.90	38.85	0.05	5.60	4.70	0.20
J-1006	66.25	67.65	0.22	67.80	65.95	0.12	37.60	36.55	0.47	3.40	3.10	0.20
HQPM-5	56.70	58.55	0.22	67.85	64.95	0.04*	40.60	38.00	0.04*	4.15	3.85	0.20
HSC-1	53.65	56.90	0.05*	81.50	76.80	0.28	49.95	46.95	0.02*	5.00	4.55	0.05*
			0.001			0.001			0.001			0.002

Table 3. Association among morphological and fodder quality traits of specialty maize

	DM	CP	CF	TA	IVDMD	NDF	ADF	ADL	DA	DS	PH	NL	LL	LW	GFY/p
DM	1.00														
CP	-0.61*	1.00													
CF	0.96*	-0.75*	1.00												
TA	-0.46*	-0.16	-0.36	1.00											
IVDMD	-0.79*	0.40	-0.80*	0.81*	1.00										
NDF	0.94*	-0.53*	0.92*	-0.26	-0.64*	1.00									
ADF	0.90*	-0.46	0.91*	-0.41	-0.77*	0.96*	1.00								
ADL	0.34	-0.42	0.53	0.07	-0.39	0.51*	0.64*	1.00							
DA	-0.86	0.77	-0.96*	0.28	0.79	-0.84	-0.89*	-0.72	1.00						
DS	-0.81	0.76	-0.93*	0.34	0.83	-0.76	-0.84	-0.72	0.99*	1.00					
PH	-0.49	0.42	-0.66	0.30	0.69	-0.55	-0.74	-0.92*	0.82	0.85	1.00				
NL	-0.39	-0.10	-0.38	0.94*	0.84	-0.25	-0.47	-0.23	0.40	0.48	0.57	1.00			
LL	-0.49	0.02	-0.53	0.77	0.84	-0.46	-0.69	-0.58	0.60	0.65	0.82	0.92*	1.00		
LW	-0.59	0.77	-0.78	0.07	0.62	-0.61	-0.70	-0.87*	0.92*	0.94*	0.90*	0.30	0.55	1.00	
GFY/p	-0.65	0.30	-0.73	0.27	0.62	-0.80	-0.91*	-0.86	0.80	0.77	0.88*	0.45	0.75	0.75	1.00

The correlations are estimated by REML method. * denotes significant at 0.05% and above

Highest values of crude protein in green forages were observed in J-1006, followed by HM-4, HQPM-5 and DHM-117 with lowest values in HSC-1 (Table 2). Protein synthesis mechanism is most active during vegetative stage and keeps on decreasing as the plants mature (Perez *et al.*, 1973). A decrease in crude protein content was observed in silage as compared to green forage. Interestingly the high concentrations of crude protein observed in baby corn hybrid (HM-4) imply that baby corn stalks were nutritious enough and can efficiently be utilized as animal fodder. Crude protein concentrations in DHM-117 and HQPM-5 were slightly lower as compared to HM-4, whereas HSC-1 showed the lowest values owing to its advanced maturity stage at the time of harvest (Table 2). However, IVDMD values were comparatively lower in HM-4 as compared to J-1006 and DHM-117 (Table 2). *In vitro* dry matter digestibility was found to be negatively correlated with advancing maturity as the plants accumulated non-digestible carbohydrate such as lignin with advance stage of maturity (Kitaba and Tamir, 2007). Similar findings were observed by Zinash *et al.* (1995) who reported reduced IVDMD of the grass species harvested at relatively advanced stages. Owing to advanced stage of maturity, HSC-1 showed highest crude fiber content followed by HM-4, HQPM-5 and DHM-117 whereas fodder maize (J 1006) exhibited lowest crude fiber values. Crude fiber is the sum of cellulose, hemicelluloses and lignin. Its higher values are considered undesirable as the increased concentration of lignin in the cell wall of the plant may significantly reduce the biomass digestibility. Similar trend was observed for other fiber components such as NDF, ADF and ADL (Table 2) with highest values exhibited by HSC-1 (sweet corn). Increased NDF was reported in forages with increasing maturity (Rinne *et al.*, 2002; Arthington and Brown, 2005; Beck *et al.*, 2007). The nutrient composition and apparent ruminal digestibility of grass were affected by stage of maturity (Salamonel *et al.*, 2012). Total mineral content (TA) had non-significant difference between green fodder and silage (Table 2). Mineral composition primarily depends upon soil profile and the harvesting stage (Khan *et al.*, 2006).

Silage is a fermented feed resulting from the storage of high moisture crops under anaerobic conditions. Preserving green forages as silage has been considered as one of the most significant technology for economical dairy farming. In spite of dry matter loss, the silage making appears to be immensely beneficial as it lowers the fiber content which is apparent from the significant decrease of crude fiber, NDF and ADF in silage as compared to green fodder in all genotypes. At the same time fermentation process in the silage leads to an increase in the IVDMD as evident from a significant increase in IVDMD values in silage as compared to green fodder of J-1006. Recently Li *et al.* (2012) observed an increased dry matter digestibility in corn silage as compared to green fodder. A significant positive correlation was observed between DM and fiber parameters (CF, NDF and ADF) whereas a negative correlation was found between DM and crude protein content.

Association of morphological and fodder quality traits: Fiber components are composed of cell wall constituents such as cellulose, hemicelluloses and lignin which contribute towards higher dry matter, thus justifying their positive correlation (Table 3). A significant negative correlation was found in crude protein and crude fiber concentrations. Crude protein was negatively correlated with ADF, NDF and cellulose (Jancik *et al.*, 2008). A significantly negative correlation was observed between IVDMD and fiber components (CF, NDF and ADF) implying that higher lignin concentrations might be responsible for lower IVDMD.

Conclusion

It was concluded that specialty maize, particularly HM-4 and HQPM-5 possess the required properties of a nutritious animal fodder as their fodder quality was almost at par to forage maize. Although the fodder quality of sweet corn variety HSC-1 was relatively poor as compared to fodder maize J-1006 but it could easily be preserved as silage. The nutritional quality of silage was superior to the green fodder in general. Silage improved digestibility significantly as it was evident from the higher IVDMD values in silage as compared to green fodder. Silage making is an important practice of preserving green forages and could be a potential substitute for green fodder in mitigating the ever increasing needs of livestock population.

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