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Adaptability, yield and *in vitro* evaluation of some promising silage maize hybrids under tropical climate

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ABSTRACT

The study was conducted to assess adaptability, yield and *in vitro* evaluation of some promising silage maize hybrids (LG 32.01, LG 34.04 and BL 4121) grown under tropical climate. The experiment was conducted in completely randomized block design with 3 replications. The stand count, plant height, number of cobs and cob length remained comparable among different maize hybrids; however, LG 34.04 variety took lesser number of days for tasselling and silking as compared to BL 4121 and LG 32.01. The BL 4121 hybrid had higher biological as well as dry matter yield as compared to LG 32.01 and LG 34.04 maize varieties. Significantly higher total digestible nutrients (TDN), relative feed quality (RFQ), digestible DM and net energy for lactation (NE_l) were detected in BL 4121 variety in comparison to other hybrids. Analogous total volatile fatty acids (tVFA), acetic acid (AA), propionic acid (PA), acetate to propionate ratio, ME value, digestibility of DM and OM were observed in *in vitro* evaluation with exception of net gas production (NGP) which was lowest for LG34.04 maize hybrid. After ensiling for 45 days, pH and lactic acid were found comparable among all selected silage maize hybrids; however, the tVFA content was recorded lowest in BL 4121 variety silage in comparison to the other hybrid silages. Furthermore, considerably higher TDN, digestible DM, NE_l, RFV and RFQ in silages prepared from LG 32.01 and LG 34.04 were reported as compared to BL 4121 silage. Therefore, BL 4121 maize hybrid was superior to other varieties in herbage yield and *in vitro* evaluation; however maize variety LG 34.04 had better nutritive value as silage for ruminants over BL 4121 and LG 32.01 under tropical climate.

Key words: Adaptability, *In vitro*, Maize hybrids, Silage, Tropical climate, Yield

India has only 2.29% of the total land area of world and hosts 17% of the human as well as 11% of the total livestock population of the world. The area under fodder production in India has declined in the past resulting in net deficit of 35.6% green fodder for livestock. If this trend continues in the future, there will be 67% deficit in the green fodder availability to the Indian livestock (Vision 2050). Moreover, under tropical climate, farmers are routinely faced with an acute shortage of green fodder twice a year particularly during November-December and May-June, known as lean periods (Chaudhary *et al*. 2012). The forage availability and its quality are major limiting factors that negatively affect animal productivity and health as well as profitability (Sirohi and Michaelowa 2007). To overcome this scenario, silage preparation is the best way to conserve the ample amount good quality fodder for the feeding of animals during the lean period. Importance of green fodder is well recognized as feeding forages alone accounts for over 60% of the cost of milk production. Hence by providing sufficient quantities of fodder instead of costly concentrates and feeds to the dairy animals, the cost of milk production can considerably be reduced (Vision 2050).

Maize is the most suitable crop for silage preparation having high concentration of soluble sugars and starch. Under Indian conditions, maize crop has an important place in the food grain basket and it is the third most important versatile food grain crop (Chaudhary *et al.* 2012). Earlier most of the breeding programmes were basically aimed at improvement of grain yield without giving much importance to its quality and yield as fodder (Walli *et al.* 1994). However, paradigm of research shifted towards the development of improved varieties of maize with better herbage yield and nutritive profiling as fodder as well as silage under the different agro-climatic conditions. Keeping pace with the need based research, Bisco Bio Sciences Pvt. Ltd. Hyderabad developed new maize hybrids, whose quality analysis as fodder and as silage is must before giving recommendation to the farmers on commercial scale. Thus the present study was undertaken to assess herbage yield, fodder *in vitro* evaluation and nutritional quality for silage of newly developed hybrids grown under tropical climate.

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MATERIALS AND METHODS

The study was carried out at Department of Animal Nutrition and Directorate Livestock Farm of the University which represents the Trans Indo-Gangetic alluvial plains. The soil of the experimental field was loamy sand in texture. The soil was neutral in reaction (pH 7.31), low in organic carbon (0.155%), low in available N (99.07 kg/ha), and medium in available P (22.16 kg/ha) and available K (185.3 kg/ha). The experiment was carried out in randomized block design (RBD) with 3 new maize hybrids (LG 32.01, LG 34.04 and BL 4121) developed by Bisco Bio Sciences Pvt. Ltd., Hyderabad and 3 replications under identical agronomic practices. The crop was sown at 60 cm row and 20 cm plant spacing. The recommended doses of N (125 kg N/ha) was applied in two splits; 1/3 N at the time sowing, 1/3 N at knee high and 1/3 at pre-tasselling stage. All the plant protection measures were taken to avoid any loss. The observations were recorded on emergence count, plant height, cob length, number of cobs, days to 50% silking and tasselling, disease incidence and biological yield. The crop was harvested when milk line was half to three-fourths down the kernel. Afterward all maize varieties were ensiled individually for 45 days in low density polypropylene tube.

In vitro *studies*: The nutritional value of fodder hybrids was assessed by *in vitro* gas production (IVGP) technique described by Menke and Steingass (1988). Rumen liquor was collected from fistulated animals maintained on conventional diet at the farm before feeding at 09:00 h in a thermos flask flushed with CO_2 and maintained at 39ºC. The rumen contents were blended for 2–3 min in a blender and strained through four-layers of muslin cloth. The solution, containing 960 ml distilled water, 0.16 ml micro-mineral solution, 660 ml bicarbonate buffer, 330 ml macro-mineral solution and 1.6 ml resazurine (0.1%) were mixed in a Woulff flask (3 Litres capacity) with magnetic stirrer in a water bath at 39ºC. The mixture was continuously flushed with CO_2. Strained rumen liquor (SRL) was added to the buffer media in the ratio of 1:2. About 375±5 mg of the dried ground baby corn fodder and conventional maize fodder (on DM basis) was incubated at 39ºC for 24 h in triplicates in 100 ml calibrated glass syringes (Haberle Labortechnik, Germany) with buffered rumen fluid for assessing the net gas production, digestibility of nutrients, VFA production and ME availability. Blank and sample of standard hay were run in triplicate with each set. Syringes were incubated in a water bath at 39ºC and swirled every 60 min over 8 h incubation period. If the volume of gas in the syringe exceeded 70 ml after 8 h, the volume was recorded and the gas was expelled (Menke *et al*. 1979, Menke and Steingass 1988). After 24 h, the volume of gas produced in each syringe was recorded and the content of syringes were transferred to spout-less beaker, boiled with neutral detergent solution for assessing the true OM and NDF digestibility. Three sets of samples were incubated, each in triplicate.

Chemical analysis: The finely ground samples of fodder and silage were analyzed for DM, CP and total ash (AOAC 2000), cellulose (Crampton and Maynard 1938) and other cell wall constituents (Robertson and Van Soest 1981). Silage samples were analyzed for pH, sugars (Dubois *et al*. 1956), lactic acid (Barker and Summerson1941), VFAs (Cottyn and Boucque 1968). The parameters TDN, NE_l,

Table 1. Physical parameters of different maize hybrids

Parameter	Maize variety			SEM	P value
	LG32.01	LG34.04	BL 4121		
Stand count (plant/m row length)	4.5	4.3	4.8	0.109	0.550
Plant height at harvest (cm)	178.9	175.3	176.3	0.877	0.054
Days to 50% tasselling**	63.3^b	57.3^a	65.4^b	0.943	0.002
Days to 50% silking***	73.3^b	67.8^a	76.4^c	0.882	0.000
Number of cobs	1.4	1.3	1.4	0.193	0.934
Cob length (cm)	20	20	21	1.139	0.705

Figures with different superscripts in a row differ significantly (**P<0.01; ***P<0.001).

Table 2. Crop yield (q/ha) and nutrient composition (% DM basis) of different maize varieties

Parameter	LG 32.01	LG 34.04	BL 4121	SEM	P value
Biological yield (q/ha)	444.5	423.6	468.3	13.314	0.144
Dry matter yield (q/ha)	159.0	148.1	169.2	10.584	0.426
Nutrient composition (% DM)					
Dry matter	35.7	34.87	36.11	0.625	0.865
Crude protein	8.53	8.28	8.22	0.140	0.905
Ether extract	2.33	2.50	2.33	0.070	0.071
Neutral detergent fibre***	48.8^b	47.6^b	45.0^a	0.624	0.000
Acid detergent fibre***	29.98^b	29.57^b	26.65^a	0.462	0.000
Acid detergent lignin	3.18	3.38	2.95	0.174	0.693
Hemicellulose**	18.8^b	18.0^a	18.3^{ab}	0.260	0.004
Cellulose	21.9	20.6	19.7	0.692	0.071
Ash	6.13	5.37	4.97	0.187	0.119
Sugar (mg %)***	11.0^b	8.10^a	10.47^b	0.678	0.000
% Digestible protein	5.97	5.79	5.75	0.196	0.905
TDN***	66.8^a	67.1^a	69.2^b	0.323	0.000
NE_l (Mcal/kg)***	1.54^a	1.57^a	1.74^b	0.0272	0.000
DDM (%)***	65.5^a	65.8^a	68.1^b	0.359	0.000
RFV***	124.9^a	128.7^b	140.7^c	2.509	0.000
RFQ***	2.93^a	3.02^a	3.39^b	0.057	0.000

Figures with different superscripts in a row differ significantly (**P<0.01; ***P<0.001). SEM, Standard error of mean; TDN, total digestible nutrients; NE_l, net energy for lactation; DDM, digestible dry matter; RFV, relative feed value; RFQ, relative feed quality.

DMI, RFV and RFQ were worked out (Schroeder 2004).

Statistical analysis: The data was analyzed by using analysis of variance (Snedecor and Cochran 1994) with SPSS (2012) version 16.0 and the means were tested for the significant difference by using Tukey's b test.

RESULTS AND DISCUSSION

Agronomic characteristic/Biometric observations: In present study, there was no incidence of Maydis Leaf Blight (MLB) *Helminthsporium maydis* and Turcicum leaf blight (TLB) *Exserohilum turcicum* diseases among different varieties of maize. MLB and TLB are prevalent in warm humid temperate to tropical regions where the temperature ranges from 20–30ºC during cropping period. No incidence of these diseases indicated better agronomic practices during the study. All the maize hybrids showed same emergence potential as there was no significant (P>0.05) difference in stand count, plant height, number of cobs and cob length (Table 1). Among the maize cultivars evaluated, LG 34.04 variety took lesser number of days for tasselling and silking as compared to other varieties. In case of LG 32.01 and BL 4121, the days to tasselling remained at par, while the number of days to silking were higher in BL 4121 variety as compared LG 32.01. Different varieties have similar agronomic characteristics so these variations might be due to the different genetic capacity of the variety (Allard 1999).

Crop yield, proximate analysis and in vitro *evaluation of different maize hybrids:* All maize varieties were harvested between 86–91 days post sowing when milk line was half to three-fourths down the kernel. Results revealed that there was no variation (P>0.05) in biological and dry matter (DM) yield (q/ha) among different selected maize varieties (Table 2). However, the BL 4121 hybrid showed higher values for studied parameters in comparison to LG 32.01 and LG 34.04 maize varieties. The results of proximate analysis (% DM basis) of different maize hybrids showed no significant difference in dry matter (DM), crude protein (CP), ether extract (EE), acid detergent lignin (ADL), hemicelluloses, cellulose, ash and digestible protein (DP) contents. DM content of ensiling crop and stage of maturity at harvest are major factors in determining the nutritive value of maize silage (Oliveira *et al*. 2017). In the present study, DM content of crops was 34.87 to 36.11% at the time of ensiling which is well within the range as described by McDonald *et al.* (1991). The maturity stage was reflected in the NDF content, ranging from 45 to 48.8% DM in the present study. These results were in concordance with the findings of Bal *et al.* (1997), Neylon and Kung (2003) and Filya *et al.* (2004), who reported that 35, 48, 28 and 3.8% (on dry basis) of DM, NDF, ADF and ADL contents, respectively in crop indicative of optimum time for harvesting maize in order to maximize yield of fermentable nutrients and production of good quality silage.

The values of water soluble sugars for pre-ensiled period in maize varieties varied significantly (P<0.001) among all hybrids with higher content in BL 4121 and LG 32.01 as compared to LG 34.04. However, the values of water soluble sugar among all varieties was adequate for producing good quality silages, as it was reported that the fodders containing initial WSC content between 60 and 80 g/kg DM is adequate to produce good quality grass silages (Woolford 1984, Pettersson and Lindgren 1990). Furthermore, total digestible nutrient (TDN %), NE_l (Mcal/kg), digestible DM (%), DM intake (% BW), relative feed value (RFV) and relative feed quality (RFQ) were also higher in BL 4121 maize variety as compared to LG 32.01 and LG 34.04 maize varieties. In addition to above results, *in vitro* study (Table 3) also revealed that the net gas production (mL/g/24 h) was higher (P<0.05) in BL 4121 and LG 32.01 maize varieties as compared to LG 34.04. However, NDF digestibility (NDFD; % DM), organic matter digestibility (OMD; % DM), ME (MJ/kg) and partitioning factor remained at par among all varieties. Similarly, the total volatile fatty acid (tVFA) production and production of individual VFA except butyric acid had shown no significant variation among the maize varieties. On the basis of above results, it could be concluded that the maize hybrid BL 4121 was superior to other varieties in crop yield and in *in vitro* evaluation however, best crop silage can be judged only after quality analysis.

Evaluation of silages prepared from different maize varieties: After 45 days, quality of silages was evaluated by recording pH, lactic acid and volatile fatty acid production. Results revealed that silage pH and lactic acid were found comparable (P>0.05) among all selected silage maize hybrids (Table 4). Silage pH and lactic acid are the indicative parameters of a good ensilage process. In current study, the pH and lactic acid were within the range of good quality silage as described by McDonald *et al.* (1991). Fermentation of water soluble sugars in forages to organic acids (mainly lactic acid) under anaerobic condition is mainly responsible for decrease in pH and level of lactic

Table 3. *In vitro* evaluation of different maize varieties

Parameter (%)	LG 32.01	LG 34.04	BL 4121	SEM	P value
NGP (ml/g/24 h**)	205.2^{b}	201.9^{a}	206.7^{b}	1.171	0.006
NDFD (%)	60.49	59.67	59.68	0.780	0.846
OMD (%)	73.16	73.15	74.46	0.629	1.220
ME (MJ/kg)	8.41	8.31	8.16	0.101	0.344
PF	1.79	1.85	2.03	0.083	0.203
Volatile fatty acid production					
TVFA	7.97	8.26	8.29	0.099	0.670
Acetic acid	5.24	5.36	5.39	0.067	0.865
Propionic acid	1.82	1.86	1.89	0.023	0.765
Isobutyric acid**	0.314	0.032	0.032	0.001	0.008
Butyric acid*	0.777^{a}	0.888^{b}	0.861^{ab}	0.015	0.011
Isovalric acid*	0.061^{a}	0.067^{ab}	0.065^{ab}	0.001	0.015
Valric acid	0.043	0.045	0.043	0.001	0.676
A:P	2.37	2.88	2.82	0.099	0.184

Figures with different superscripts in a row differ significantly (**P<0.01; ***P<0.001). SEM, Standard error of mean; NGP, net gas production; NDFD, neutral detergent fibre digestibility; OMD, organic matter digestibility; ME, metabolizable energy; PF, partitioning factor; TVFA, total volatile fatty acids; A:P, acetate to propionate ratio.

Table 4. pH, lactic acid and VFA production in silages of different maize varieties

Parameter	LG 32.01	LG 34.04	BL 4121	SEM	P value
pH	4.04	4.16	4.10	0.030	0.062
Lactic acid (mg/g)	0.14	0.16	0.14	0.007	0.151
TVFA**	5.53^{b}	6.00^{b}	3.47^{a}	0.320	0.006
Acetic acid**	2.93^{b}	2.70^{b}	1.64^{a}	0.020	0.009
Propionic acid*	2.17^{a}	2.69^{b}	1.66^{a}	0.012	0.015
A:P*	1.33^{b}	1.02^{a}	1.01^{a}	0.065	0.018

Figures with different superscripts in a row differ significantly (*P<0.05; **P<0.01; ***P<0.001). SEM, Standard error of mean; TVFA, total volatile fatty acids; A:P, acetate to propionate ratio.

Table 5. Nutrient composition of silages prepared from different maize varieties

Parameter (%)	LG 32.01	LG 34.04	BL 4121	PSE	P value
Dry matter	35.53	35.23	35.57	0.623	0.675
Crude protein	7.88	7.80	7.65	0.097	0.877
Ether extract	2.68	2.60	2.13	0.094	0.158
Neutral detergent fibre**	42.2^{b}	42.3^{b}	41.6^{b}	0.186	0.002
Acid detergent fibre***	27.6^{b}	26.45^{b}	31.17^{c}	0.603	0.000
Acid detergent lignin*	4.15^{a}	3.58^{a}	4.90^{b}	0.199	0.041
Hemicellulose***	14.6^{b}	15.85^{b}	10.43^{a}	0.620	0.000
Cellulose	24.67	23.70	23.83	1.111	0.819
Ash	5.17	5.36	5.07	0.080	0.318
Sugar (mg %)***	4.42^{c}	1.35^{a}	2.13^{b}	0.446	0.000
% Digestible	5.52	5.46	5.35	0.068	0.877
TDN***	68.55^{b}	69.35^{c}	66.05^{a}	0.422	0.000
NE_l, (M cal/kg)***	1.70^{b}	1.77^{c}	1.49^{a}	0.035	0.000
% DDM***	67.39^{b}	68.29^{c}	64.62^{a}	0.269	0.000
RFV***	148.6^{b}	150.2^{b}	144.5^{a}	1.29	0.000
RFQ***	3.48^{b}	3.51^{b}	3.40^{a}	0.028	0.000

Figures with different superscripts in a row differ significantly (*P<0.05; **P<0.01; ***P<0.001). SEM, Standard error of mean; TDN, total digestible nutrients; NE_l, net energy for lactation; DDM, digestible dry matter; RFV, relative feed value; RFQ, relative feed quality.

acid (Borreani *et al.* 2018). During the present study, the decrease in water soluble sugar (Table 5) content after ensiling was more in LG 34.04 variety followed by BL 4121 and LG 32.01, which led to similar pH and lactic acid content in all silages despite of significant variation of soluble sugar in the pre-ensiled maize variety. The total VFA content also varied significantly (P<0.05) among different hybrid silages and the value observed was lowest in BL 4121 variety silage. Moreover, BL 4121 variety silage had lowest acetic acid and propionic acid production compared to LG 32.01 and LG 34.04 variety silage, respectively. Evaluation (% dry matter basis) of different silages showed raised hemicellulose, TDN, NE_l (Mcal/kg), digestible DM, RFV and RFQ content in silages prepared from LG 32.01 and LG 34.04 maize varieties in comparison to BL 4121 silage and the values were highest for LG 34.04 variety silage (Table 4). High TDN and NE_l content of silage reflected optimum energy density which could maximize production efficiency of lactating animals, as dietary energy is a major factor affecting the animal performance (Moore *et al.* 1999). Furthermore, higher RFV and RFQ values are the confirmation to good quality silage because these indices include both voluntary intake of forage when fed as the sole source of energy and protein, and some measure of available energy (Moore and Undersander 2002).

Amongst the 3 selected maize hybrids, BL 4121 emerged as the superior cultivar with respect to herbage yield, total digestible nutrients, relative feed quality, digestible dry matter, net energy for lactation and *in vitro* performance; however, maize variety LG 34.04 had better nutritive value as silage for ruminants over BL 4121 and LG 32.01 under tropical climate.

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