



Proximate principles and dry matter digestibility of fodder maize and sugargraze in response to potassium management

R K MAHANTA¹, R K MEENA^{1✉}, RAKESH KUMAR¹, HARDEV RAM¹, M SINGH¹, A BHAKAR², D KUMAR¹ and S BHATTACHARJEE¹

ICAR-National Dairy Research Institute, Karnal, Haryana 132 001 India

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ABSTRACT

The study was carried out to evaluate the forage quality of maize and sugargraze as influenced by different potassium management practices. The experiment was laid out in split-plot design in which two fodder crops, viz. maize and sugargraze, were taken as the main plot, and different potassium management regimes were taken as a subplot. Results revealed that the quality parameters of sugargraze and fodder maize crops, viz. Dry matter, crude protein, ether extract, ash content, neutral detergent fibre, acid detergent fibre, and acid detergent lignin were significantly influenced favourably by potassium management. Comparing the quality parameters, remarkably highest CP (9.70%), total ash content (9.87%) as well as potassium uptake (230 kg/ha) were obtained with 50 kg K₂O + KSB + 2% KNO₃ foliar spray; however, higher ether extract (1.73%) was recorded in 50 kg K₂O + KSB + 2% K₂SO₄ foliar spray. The fibre fractions, viz. NDF (66.1%), ADF (35.4%) and ADL (4.70%) recorded considerably lower values with 25 kg K₂O + KSB + 2% KNO₃ foliar spray over control. The higher values of TDN (59.3%), DMD (63.6 g/kg), RFV (94.7%) and DMI (1.92 g/kg) were recorded in fodder maize over sugargraze with an application of 25 kg K₂O + KSB + 2% KNO₃ foliar spray. Therefore, considering all the studied parameters, it can be concluded that getting higher quality green biomass production of fodder maize and sugargraze with the application of 25 kg K₂O + KSB + 2% KNO₃ would be a more feasible agro-practice.

Keywords: Fodder quality, Maize, Potassium management, Sugargraze

Livestock production is an integral and indispensable component of any farming system in agriculture. India is ranked 1st in milk production, contributing 24% of global milk production, although the productivity of Indian livestock (1538 kg/lactation) is far below the world average (2238 kg/lactation) (Kour *et al.* 2023). For this poor productivity, a major constraint is the unavailability of quality feed and fodder throughout the year. India has had only 5.4% of the total cropping area under fodder cultivation, resulting in a severe deficit of feed and fodder for livestock. This constitutes about 60–70% of the cost of milk production, and green fodder is one of the best and cheapest sources of supply for animals' energy and nutritional requirements (Raj *et al.* 2023). Productivity and quality of fodder are positively correlated with soil nutrient status, as nutrient deficient soil has a significant impact on crop production as well as the quality of plant produce (Morgan and Connolly 2013). As a result, balanced crop fertilisation is an essential agro-intervention for producing high-quality produce. Potassium is known as a major plant

nutrient that may help to maintain and improve the quality aspects of crops, and its management may play a major role in reducing the gap. Maize and sugargraze are popular fodder crops with a more significant share in supplying quantity and quality-rich green fodder to animal diets. Hence, to obtain the best quality fodder through potential fodder crops like maize and sugargraze, coherent and eco-friendly agro-interventions are essential for potassium management.

MATERIALS AND METHODS

The experiment was carried out at the Research Farm of the Agronomy, ICAR-National Dairy Research Institute, Karnal during the *kharif* season of 2018. This region experiences both high (up to 45°C) and low temperatures (near to 3–4°C) in summer and winter, respectively. The experiment was laid-out in Split Plot Design with 16 treatment combinations, replicated thrice. In the main plot, two fodder crops, viz. fodder maize and sugargraze, while potassium management options were investigated in the subplot. The crops, sugargraze @ 12 kg/ha seed rate and fodder maize cv. J-1006 @ 50 kg/ha seed rate were sown during the 31st standard meteorological week. At the age of 50% flowering stage, the crops were harvested and fresh forage yield was recorded. Fresh green samples were

Present address: ¹ICAR-National Dairy Research Institute, Karnal, Haryana. ²ICAR-Indian Agricultural Research Institute, New Delhi. ✉Corresponding author email: rajeshkumar2793@gmail.com

weighed from each plot, and representative samples were oven-dried at 65°C for 72 h or until a constant weight was achieved for dry-matter (DM) estimation. The dried samples were ground separately (Wiley mill) to pass through a 1 mm sieve and used for further chemical analysis.

Proximate analysis of DM, ash content, ether extract and nitrogen (AOAC 2005) and fibre fractions (Van Soest *et al.* 1991) were estimated using given standard methods. The secondary quality indices (TDN, DMI, DMD and RFV) were computed according to the methodology given by Lithourgidis *et al.* (2006). The statistical analysis was carried out using Fisher's variance technique analysis and the least significant difference test at the 5% probability level. The data were analyzed in SAS version 9.3 (SAS Institute Inc, Cary, NC), taking into account the experiment's split-plot structure.

RESULTS AND DISCUSSION

Effect of potassium management on fodder yield:

Green fodder yield is a prime factor in determining the productivity of fodder crops and the efficacy of applied agronomic practices. It was noticed that, crop sugargraze recorded statistically higher green and dry fodder yields (30 and 41%) over maize respectively. This might be due to sugargraze having comparatively higher genetic growth potential (plant height, more nodes/plant exhibited more maximum leaves, increased girth size and extensive root system) over maize crop. Forage sorghum has a large root system that allows it to access water and nutrients at greater depths in the soil and produces a higher biomass (Gao *et al.* 2022). These results were in close agreement with the outcome of Kar *et al.* (2017). The application of potassium also made significant differences in fodder yield. The treatment $K_{50} + KSB + 2\% KNO_3$ had obtained significantly higher green and dry fodder yield (57.4 and 12.4 t/ha),

respectively, which remained at par with the treatments $K_{50} + KSB + 2\% K_2SO_4$ and $K_{25} + KSB + 2\% KNO_3$ and at par with rest of treatments. The higher green fodder yield in $K_{50} + KSB + 2\% KNO_3$ may be because of potassium solubilizing bacteria (KSB) and foliar spray of potassium nitrate ensured the uniform availability of nutrients like nitrogen and potassium, which enhanced the growth parameters (plant height, leaf length, width, and the number of leaves) which ultimately reflected higher total green fodder yield. Improvements in crop productivity might be the result of maintaining osmotic adjustment, stomatal regulation and higher shoot biomass and photosynthetic activity owing to potassium application (Moinuddin and Imas 2010). These results were in accordance with the findings of Amanullah and Irfanullah (2016) in the maize crop.

Potassium content and uptake by maize and sugargraze:

Being a primary nutrient, potassium is essential for growth and development, and helps enhance produce quality. Data on potassium content (%) and uptake (kg/ha) (Table 1) revealed that fodder maize and sugargraze did not show any significant differences in plants K content. However, significantly higher K uptake was recorded by sugargraze to the tune of 42.5% higher than fodder maize. The higher K uptake might be attributed due to the significant difference in biomass production potential showed by sugargraze than fodder maize.

Potassium nutrition significantly influenced K content and uptake by the fodder crops and the treatment of $K_{50} + KSB + 2\% KNO_3$ recorded significantly higher values of content (1.73%) and uptakes (230 kg/ha) over control, KSB, and K_{40} . The variation in K uptakes was higher than content and the treatment $K_{50} + KSB + 2\% KNO_3$ performed statistically higher on all treatments except the treatment $K_{50} + KSB + 2\% K_2SO_4$. This might be due

Table 1. Effect of potassium management on proximate parameters of fodder maize and sugargraze

Fodder crop	K content (%)	K uptake (kg/ha)	D.M. (%)	C.P. (%)	E.E. (%)	Total ash (%)
Maize	1.62	155.94	21.51	9.10	1.62	8.89
Sugargraze	1.67	222.30	23.05	9.52	1.71	9.42
SEm ($\pm$)	0.01	4.05	0.19	0.06	0.01	0.05
LSD (P=0.05)	NS	24.66	1.14	0.36	0.08	0.30
<i>K management</i>						
K_0 – Control	1.52	145.21	21.56	8.94	1.59	8.13
K_1 – KSB	1.53	155.62	21.90	8.97	1.60	8.24
K_2 – K_{40}	1.63	172.45	21.90	9.13	1.66	9.08
K_3 – K_{60}	1.71	195.25	21.84	9.35	1.67	9.27
K_4 – $K_{25} + KSB + 2\% K_2SO_4$	1.66	193.58	22.39	9.28	1.71	9.29
K_5 – $K_{25} + KSB + 2\% KNO_3$	1.67	205.14	22.83	9.60	1.67	9.54
K_6 – $K_{50} + KSB + 2\% K_2SO_4$	1.72	215.97	22.65	9.52	1.73	9.79
K_7 – $K_{50} + KSB + 2\% KNO_3$	1.73	229.77	23.19	9.70	1.72	9.87
SEm ($\pm$)	0.02	8.13	0.77	0.08	0.02	0.17
LSD (P=0.05)	0.07	23.54	NS	0.24	0.07	0.51

K, Potassium; DM, Dry matter; OM, Organic matter; CP, Crude protein; EE, Ether extract; KSB, Potassium solubilizing bacteria; K_2SO_4 , Potassium sulphate; KNO_3 , Potassium nitrate.

to the beneficial effect of KSB and foliar application of KNO_3 on sufficient amounts of plant-available K. These results concur with those presented by Badr *et al.* (2006). The overall increased concentration of plant nutrients under K applied plots over control might be due to higher availability of potassium because it has played a vital role in the translocation of nutrients in the plants on the one hand, and on the other hand, it has a synergistic effect on the uptake of nitrogen and phosphorus. The present results conform with Moinuddin and Imas (2010) finding in forage sorghum.

Effect of K management on fodder quality parameters: Results revealed that fodder crops and potassium management had a significant effect on fodder quality parameters (Dry matter, crude protein, ether extract and total ash content) at harvest (Tables 2 and 3). The dry matter (DM) content was recorded as significantly higher in sugargraze (23.1%) over fodder maize (21.5%). This might be due to its different genetic constituents and performance potentials under varying input management conditions. The higher physiological activities in plants helped realize more significant DM accumulation (Das *et al.* 2006). Crude protein (CP) is an important quality indicator and requires daily animal maintenance, lactation, growth and reproduction. Sugargraze crop had a 5% higher CP than maize, which was statistically higher. Ether extract (EE) is approximately the total fat (or crude fat) content of fodder and is significantly influenced by different crops. The EE in the sugargraze was approximately 5.5% higher than the fodder maize. The ash content is the inorganic residue that approximates the total minerals present in feed and fodders. The approximately 6.0% higher ash content was obtained in sugargraze as compared to fodder maize. The crop sugargraze has a deeper and more extensive root system than maize, which absorbs higher plant nutrients and influenced lower environmental stress. The differential

response of crops/cultivars is mainly due to their genetic variations and ability to absorb soil nutrients and accumulate them in their plant metabolic system (Krishna 2010).

The effect of potassium treatments on quality parameters (CP, EE and Ash content) was found significant, except for DM content (Table 2). The DM content with the application of $\text{K}_{50} + \text{KSB} + 2\% \text{KNO}_3$ was 6.2% higher than the treatment of K_{60} . The highest CP content was recorded with an application of $\text{K}_{50} + \text{KSB} + 2\% \text{KNO}_3$ (9.70%), which was found at par with other treatments, except $\text{K}_{25} + \text{KSB} + 2\% \text{KNO}_3$ and $\text{K}_{50} + \text{KSB} + 2\% \text{K}_2\text{SO}_4$. The increase in CP values of $\text{K}_{50} + \text{KSB} + 2\% \text{KNO}_3$ was 8.5 and 3.7% over to K_0 and K_{60} , respectively. The higher protein content of $\text{K}_{50} + \text{KSB} + 2\% \text{KNO}_3$ might be due to N and K availability through foliar application of KNO_3 , which enhanced the amino acid formation, increasing protein content. It may be related to the fact that potassium increases the use of nitrogen, which enhances the characteristics of cell growth and expansion (Nascimento *et al.* 2021). Wichman (2001) also supported these results, who revealed that K fertilization had a synergistic effect on crude protein. K management also influenced the EE, and the highest values (1.73%) were obtained in $\text{K}_{50} + \text{KSB} + 2\% \text{K}_2\text{SO}_4$. Applying $\text{K}_{50} + \text{KSB} + 2\% \text{K}_2\text{SO}_4$ was at par with other combinations, except K_0 and KSB. The higher EE content with K management might be since K and sulphur (S) are involved in activating many enzymes used in photosynthesis, starch formation, protein synthesis, and improving oil concentration. The N and S exhibited strong interdependence on effecting significant yield and quality improvements in several crop species. These results are in close conformity with those reported by Zenda *et al.* (2021). Likewise, the application of $\text{K}_{50} + \text{KSB} + 2\% \text{KNO}_3$ exhibited significantly higher total ash content (9.87%) and it was 21.4 and 6.5% higher compared to treatments K_0 and K_{60} , respectively. The total ash content increased with increasing nutrients, implying

Table 2. Effect of potassium management on fodder quality of maize and sugargraze

Fodder crop	NDF (%)	ADF (%)	ADL (%)	Hemi-cellulose (%)	O.M. (%)	Total CHO (%)
Maize	64.38	33.81	5.07	30.57	91.11	80.39
Sugargraze	70.89	40.08	4.81	30.81	90.58	79.35
SEm ($\pm$)	0.29	0.29	0.04	0.47	0.01	0.09
LSD (P=0.05)	1.78	1.74	NS	NS	0.08	0.57
<i>K management</i>						
K_0 – Control	69.68	38.30	5.30	31.38	91.87	81.34
K_1 – KSB	69.32	38.10	5.15	31.22	91.76	81.20
K_2 – K_{40}	66.78	36.78	4.67	30.00	90.92	80.14
K_3 – K_{60}	68.16	37.45	5.07	30.71	90.73	79.72
K_4 – $\text{K}_{25} + \text{KSB} + 2\% \text{K}_2\text{SO}_4$	66.17	35.97	4.79	30.20	90.71	79.72
K_5 – $\text{K}_{25} + \text{KSB} + 2\% \text{KNO}_3$	66.07	35.37	4.70	30.70	90.46	79.19
K_6 – $\text{K}_{50} + \text{KSB} + 2\% \text{K}_2\text{SO}_4$	67.70	37.10	5.01	30.60	90.21	78.96
K_7 – $\text{K}_{50} + \text{KSB} + 2\% \text{KNO}_3$	67.23	36.52	4.86	30.71	90.13	78.72
SEm ($\pm$)	0.76	0.62	0.14	0.86	0.02	0.18
LSD (P=0.05)	2.22	1.79	0.42	NS	0.07	0.53

NDF, Neutral detergent fibre; ADF, Acid detergent fibre; ADL, Acid detergent lignin; OM, Organic matter; CHO, Carbohydrates.

Table 3. Correlation coefficient (r) between green fodder yield and different quality parameters

	GFY	DM	CP	EE	ASH	NDF	ADF	ADL
<i>Maize</i>								
GFY	1.00							
DM	0.77*	1.00						
CP	0.96**	0.69	1.00					
EE	0.92**	0.73*	0.80*	1.00				
ASH	0.98**	0.74*	0.94**	0.96**	1.00			
NDF	-0.79*	-0.61	-0.73*	-0.73*	-0.79*	1.00		
ADF	-0.78*	-0.68	-0.67	-0.80*	-0.78*	0.87**	1.00	
ADL	-0.59	-0.56	-0.45	-0.63	-0.59	0.89**	0.87**	1.00
<i>Sugargraze</i>								
GFY	1.00							
DM	0.94**	1.00						
CP	0.94**	0.96**	1.00					
EE	0.89**	0.77*	0.80*	1.00				
ASH	0.86**	0.80*	0.88**	0.89**	1.00			
NDF	-0.38	-0.44	-0.45	-0.56	-0.58	1.00		
ADF	-0.44	-0.60	-0.67	-0.40	-0.65	0.79*	1.00	
ADL	-0.37	-0.44	-0.52	-0.48	-0.72*	0.84**	0.85**	1.00

GFY, Green fodder yield; DM, Dry matter; OM, Organic matter; CP, Crude protein; EE, Ether extract; CHO, Carbohydrates; NDF, Neutral detergent fibre; ADF, Acid detergent fibre; ADL, Acid detergent lignin; HC, Hemicellulose; *, correlation significant at 5% level and **, correlation significant at 1% level.

that more minerals were accumulated when KSB was added to the soil and foliar fertilization of KNO_3 .

Fibre fractions: Low fibre fraction content is presumed to be good quality fodder. NDF and ADF content in fodder maize were 9.2 and 15.7% lower, respectively than in sugargraze, which indicates that maize is better than sugargraze in terms of fodder quality. Zampaligre *et al.* (2021) revealed a lower fibre fraction and superior in-vitro digestibility and metabolized energy in forage maize as compared to sorghum and perarmillet. However, in response to potassium management, a significantly lower value of NDF and ADF (66.1 and 35.4%) were recorded with $\text{K}_{25} + \text{KSB} + 2\% \text{KNO}_3$. These results are in line with the findings of Ahmad *et al.* (2009). The lower fibre fractions were obtained with $\text{K}_{25} + \text{KSB} + 2\% \text{KNO}_3$ which might be because an appropriate and balanced amount of K and N (KNO_3) resulted in the rapidly synthesised carbohydrates being converted into proteins and protoplasm, and only smaller portions were available for cell wall material. The results were in close conformity with the findings reported by Ayub *et al.* (2002). Data presented (Table 2) indicated that the ADL and hemicellulose content of fodder maize and sugargraze were found to be non-significant. The higher OM (%) and total CHO (%) content were also reported in fodder maize over sugargraze. However, with the response to potassium management, significantly lower ADL content was recorded in $\text{K}_{25} + \text{KSB} + 2\% \text{KNO}_3$ (4.7%) over control (K_0) and KSB, which was statistically at par with the rest of the treatments. Whereas, potassium treatments failed to exert any considerable difference in the hemicellulose content of fodder crops. The higher OM content and total CHO were recorded with control (K_0). This might be due

to a corresponding increase in ash content as influenced by potassium applications.

Correlation studies between quality parameters and fodder yield: All possible correlation matrixes on fodder quality of maize and sugargraze are tabulated in Table 3. Quality enhancing attributes of maize, viz. DM (0.77), CP (0.96), EE (0.92), Ash (0.98) were positively correlated whereas quality diminishing attributes, viz. NDF (-0.79), ADF (-0.78), ADL (-0.59) were negatively correlated with GFY, respectively. Also other quality parameters (DM, CP, EE, Ash) were negatively correlated with quality diminishing parameters, viz. NDF (-0.61, -0.73, -0.73, -0.79), ADF (-0.68, -0.67, -0.80, -0.78), ADL (-0.56, -0.45, -0.63, -0.59) with DM, CP, EE and TA, respectively. Similar results were obtained by sugargraze also and quality attributes, viz. DM (0.94), CP (0.94), EE (0.89), Ash (0.96) were positively correlated whereas quality diminishing attributes, viz. NDF (-0.38), ADF (-0.44), ADL (-0.379) were negatively correlated with GFY.

Nutritional indices: Dry matter intake (DMI) is negatively correlated with NDF content and is an essential parameter of fodder quality. Digestibility is a crucial aspect of measuring the nutritive value of animal feed/ fodder. Dry matter digestibility (DMD) is the dry matter portion of a feed that animals digest at a specified feed intake level. Total digestible nutrients (TDN) represent the energy content and digestibility of feed/ fodder. Relative feed value (RFV) is an index used to compare the quality of forages concerning consumption and digestibility. An appraisal of data illustrated in Fig.1 revealed that dry matter intake, dry matter digestibility, total digestible nutrients and relative feed values of maize were found (10.7, 8.5, 16.3 and 19.4%)

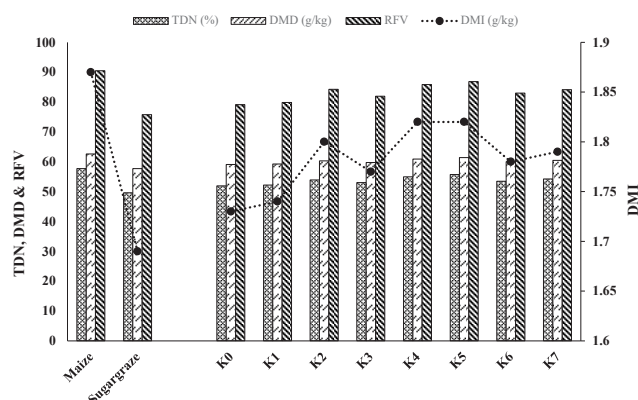


Fig. 1. Fodder quality indices of maize and sugargrass crops (TDN, Total digestible nutrients; DMD, Dry matter digestibility; RFV, Relative feed value and DMI, Dry matter intake).

higher, respectively than sugargrass. Zampaligre *et al.* (2021) reported that maize fodder had good IVDOM value and has potential for quality fodder production. Potassium management had a significant influence on all indices and higher values of DMI, DMD, TDN and RFV were recorded in the $K_{25} + KSB + 2\% KNO_3$ treatment. These results would be due to the precise and optimum doses of potassic fertilizers with KSB application.

This study indicated that applying 25 kg K_2O + potassium solubilizing bacteria + 2% potassium nitrate foliar application with a recommended dose of nitrogen and phosphorus in fodder maize and sugargrass would be a better option for enriching the nutritive values while the digestibility indices of maize were superior to those of sugargrass.

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