Indian Journal of Animal Sciences **88** (8): 944–948, August 2018/Article

Effect of feeding micronutrient fertilized sorghum hay based diet on nutrient utilization and mineral balance in sheep

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Received: 9 March 2018; Accepted: 17 May 2018

ABSTRACT

The present work was undertaken to study the effect of feeding micro-nutrient rich sorghum hay in the diet of sheep on nutrient intake and its utilization. Twelve adult *Jalauni* sheep (weighing 39.11±1.02 kg) were randomly divided into 2 groups of 6 animals each. The sheep of control group (G1) were fed on NPK fertilized chopped sorghum hay and crushed barley grain (300g/d) based ration, while the sheep of group G2 were offered NPK + 50% recommended dose of micronutrients (Zn, Mn and Cu 10, 5 and 2.5 kg/ha) + seed priming in 0.05% solution of $ZnSO_4$ for 12 h + VAM inoculated sorghum hay along with barley grain (300g/d) for 30 days. Micro-nutrient (Cu, Zn and Mn) fertilization improved mineral content (ppm) in sorghum hay for Cu (7.47 vs 9.22), Zn (22.69 vs 27.48) and Mn (73.56 vs 102.01). The effective intake of minerals was Cu, 8.71and 10.06, Zn, 26.23 and 30.18; Mn, 62.59 and 86.05 ppm in G1and G2, respectively. The additional mineral supplementation through micronutrient rich sorghum hay had no significant effect on dry matter intake. Similarly, the intakes of digestible crude protein, metabolizable energy and digestibility of DM, CP, NDF, ADF, were also comparable among the groups. However, micro-nutrient (Cu, Zn and Mn) supplementation through fodder sorghum improved the mineral retention (Cu 2.84 vs 3.72 mg/d, Zn 11.72 vs 15.46 mg/d and Mn 26.19 vs 40.28 mg/d) without affecting significantly the absorption coefficient in adult sheep. The apparent absorption and retention of N was positive and comparable between the groups. Nutrient content (%) in terms of DCP and TDN in both type diets fed to sheep were also similar. Thus, it can be concluded that micro-nutrient (Cu, Zn and Mn) application to fodder sorghum improved the mineral content in the fodder, and feeding of micronutrient fertilized sorghum hay based diet improve the intake and retention of micro-minerals significantly without affecting nutrient intake and nutrient utilization in adult *Jalauni* sheep.

Key words: Fodder sorghum, *Jalauni* sheep, Micronutrient fertilization, Mineral retention, Nutrient utilization

Soils from all over country have been found depleted for Cu, Zn, P and S in soil, plants and dairy cows (Garg *et al*. 2003, Devi *et al*. 2014) and it was observed that most of the crop residues are deficient in Cu and Zn (Gowda *et al*. 2004a). Bhanderi *et al*. (2015) reported high incidences of forage and blood serum samples below the critical levels for Cu and Zn. Lactating cows and mature animals are found malnourished and unable to meet their requirement of Ca, P, Cu and Zn from forages available to the livestock (Bhanderi *et al*. 2016). Copper and zinc play an important role in metabolism of animals and regular supply of these minerals in ration of animals improve their growth, reproduction, immunity, health and productivity (Haenlein 2004). Zinc (Zn) is an essential trace element for both animals and microorganisms in the rumen and is required for several metabolic functions as well (Eryavuz and Burk 2009). Digestibility of dry matter (DM), organic matter, and crude protein (CP) increased in goats when the diets were supplemented with 1 g/day organic Zn (Salama Ahmed *et al*.2003).The deficiency of Cu and Zn is a common problem in sheep under prevailing system of rearing on degraded grazing lands in semiarid (Shinde and Sankhyan 2007). In tropical conditions like India, sheep mainly thrive on poor quality roughages and fallen leaves. Therefore, there is a need to determine the optimum concentration of different minerals in diet for developing effective supplementary package. Forage crops are highly responsive to fertilizers, particularly N, P, S, Zn and substantial improvement in yield and nutritional quality can be achieved through balanced nutrition. Hence, agronomic fortification as short-term plan may provide a suitable strategy for correction of micronutrient deficiency in forages. The present investigation was carried out to study the effects of feeding micronutrient fertilized sorghum hay based diet on nutrient utilization and mineral balance in sheep.

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MATERIALS AND METHODS

Sorghum fodder was grown at central experimental farm of Indian Grassland and Fodder Research Institute, Jhansi during *Kharif* (autumn) with application of NPK only without micronutrient and with 50% recommended dose of micronutrients (Zn, Mn and Cu 10, 5 and 2.5 kg/ha) + *Vesicular*-arbuscular mycorrhiza (VAM) + seed priming (soaked for 12 h in .05% solution of $ZnSO_4$) and harvested at 100% flowering stage. Hay was prepared after drying in the sun.

Twelve adult *Jalauni* sheep (Average body weight 39.11±1.02 kg) were divided into 2 groups of 6 animals each. In control group (G1), the animals were fed sorghum hay (untreated) *ad lib.* while the animals of G2 group were fed micronutrient fertilized sorghum hay based diet. Both the groups were supplemented with 300 g crushed barley grain for 30 days. All the animals were dewormed with broad spectrum anthelmintic. The animals were kept in well ventilated shed having the facility of individual feeding. Diet was offered in individual trough once daily at 9.30 a.m. After adaptation period of 21 days, a 6-day metabolism trial was conducted; feed residues, faeces and urine were collected, sampled at 24 h intervals and pooled for 6 days for analysis (Schneider and Flatt1975). Proportional aliquots of wet faeces were weighed and mixed thoroughly with adequate amount of 25% sulphuric acid for preservation to await the analysis for nitrogen. Similarly, urine aliquots were collected in bottles containing sulphuric acid and stored at –10°C. Faeces were oven dried (70°C) to constant weight for other analysis. Dried samples were ground in a hammer mill; passed through 1 mm pore size sieve before analysis. Representative samples of feeds offered, residues and excreta (faeces/urine) were analyzed for proximate principles like moisture/dry matter (DM), crude protein (CP), ether extracts (EE) and total ash contents as per AOAC (1995), and cell wall fractions (Goering and Van Soest 1970). CP content (N×6.25) was determined by microkjeldahl distillation method (AOAC 1995). Feed, urine and faeces samples were digested in tri-acid (HNO_3:H_2SO_4:$HClO_4$ in the ratio of 15:2:4) and volume was made to 50 ml and subsequently, zinc, copper and manganese in experimental samples were determined using Atomic Absorption Spectrophotometer (VARIAN AA 240). Metabolizable energy (ME) intake was calculated by the formulae MEI = OMI, g × 19 × 0.82 (ARC 1980). Data were analysed statistically using 't' test (Snedecor and Cochran 1994) with SPSS package programme.

Table 1. Chemical composition of sorghum hay and crushed barley grain

Attributes	Sorghum hay (C)	Sorghum hay (F)	Barley grain (crushed)
DM	89.69	91.20	95.72
OM	93.81	93.04	96.94
CP	6.44	6.63	10.80
EE	2.12	2.24	1.68
NDF	68.59	71.51	40.04
ADF	43.96	43.76	10.45
CF	26.18	27.13	3.42
Cellulose	33.76	34.52	4.26
NFE	59.07	57.04	81.04
ADL	5.12	5.26	1.05
Zn (ppm)	22.69	27.48	27.6
Cu (ppm)	7.47	9.22	8.60
Mn (ppm)	73.56	102.01	14.50

C-Control, F-micronutrient fertilized.

RESULTS AND DISCUSSION

Treated or untreated sorghum hay was analyzed for proximate composition, fiber fractions and micronutrient contents (Table 1). Crude protein and fiber content in treated or untreated sorghum hay was comparable and similar with the earlier observations of Thomas *et al*. (2013). Owing to the application of micronutrient, there was an increase in Zn, Cu and Mn concentration (ppm) to the tune of 21.11%, 23.43% and 38.67%, respectively, in treated sorghum hay. Similar to present findings, Sahrawat *et al*. (2008) and Ahmad *et al*. (2007) recorded higher Zn concentration in the straws of sorghum, maize and rice with the application of balanced mineral nutrients (through S, B, Zn, N, and P fertilization).Borges *et al*. (2009) also observed that maize hybrids accumulated greater amounts of B, Zn, Mn and Cu in above ground biomass with Zn fertilization close to physiological maturity. Zinc is an activator of many enzymes involved in photosynthesis, cell elongation and cell division. Thus yield, crude protein and zinc concentration are significantly affected by zinc fertilization (Safak *et al*. 2009).

The average values of daily DMI (Table 2) were similar between the groups. Though an apparent improvement in feed intake per 100 kg body weight (2.72 vs 2.81) or metabolic body size (68.74 vs 70.25) was observed in G2, but the values were statistically nonsignificant ($P>0.05$). Similarly, Shinde *et al*. (2013) reported comparable daily dry matter intake in lambs fed Cu and Zn supplemented diet. No change in feed intake was also reported in *Muzafarnagri* lambs (Garg *et al*. 2008), in bulls (Mandal *et al*. 2007) and in Cashmere goats (Wenbin *et al*. 2008) when Zn was supplemented to a basal diet. Malcolm-Callis *et al*. (2000), however, reported a linear decrease in the DMI with the increasing concentration (20, 100 and 200 mg/kg DM) of Zn in the diet (having 70 mg Zn/kg) in beef steers. But it might be due to very high intake of Zn (being 90, 170 and 270 mg/kg DM, respectively) in these animals. Contrary to present findings, Zeleke *et al*. (2015) reported higher total DMI in sheep receiving commercial mineral mix (CM) compared to other treatment groups ($P<0.001$). This might be due to higher level of minerals in commercial mineral mix that abounding better mineral to rumen microbial activity. Digestibility of DM, OM, NDF, ADF and CP were comparable in sheep fed either treated (micronutrient fertilized) or untreated sorghum hay based diet. Mondal *et al*. (2004) suggested no improvement in digestibility of DM, CP and NDF in goats which supporting the results of present study. Mishra *et al*. (2016) also observed that the supplementation of micronutrient in the diet of crossbred calves did not affect the intake and digestibility coefficients of CP, EE, NDF and ADF. There

Table 2. Nutrient utilization in sheep fed micronutrient fertilized sorghum hay based diet

Parameter	G1	G2	't' value
DMI (g/d)	1079±13.12	1089±19.64	0.15
DMI (%)	2.72±0.14	2.81±0.12	0.36
DMI (g/kg $W^{0.75}$)	68.74±4.10	70.25±4.04	0.34
OMI (g/kg $W^{0.75}$)	64.64±1.99	65.62±3.87	0.23
NI (g/kg DOMI)	23.53±0.95	23.76±1.49	0.11
DCPI (g/kg $W^{0.75}$)	2.34±0.03	2.41±0.04	1.05
TDNI (g/kg $W^{0.75}$)	34.32±1.15	32.24±2.51	0.75
MEI (MJ/kg $W^{0.75}$)	1.01±0.03	1.02±0.05	0.23
Digestibility coefficients (%)			
DM	57.78±0.87	59.69±3.07	0.64
OM	60.28±0.76	61.58±3.04	0.46
NDF	54.03±1.26	56.23±4.38	0.69
ADF	48.93±1.33	50.02±3.65	0.32
CP	46.77±0.84	47.57±0.99	0.21
EE	66.75±1.81	67.96±2.06	0.44
NFE	61.29±0.33	60.91±3.40	0.82
N balance (g/d)			
N intake	14.37±0.47	14.68±0.39	0.71
Fecal N	7.66±0.37	7.75±0.58	0.13
Urine N	3.32±0.32	3.64±0.28	1.05
N retention	3.39±0.31	3.28±0.66	0.96
N retained % of intake	23.59±1.79	22.65±3.62	0.24
N retained% of absorbed	50.36±3.23	46.52±5.61	0.67
Density of nutrients (%)			
DCP	3.89±0.14	3.98±0.15	0.39
TDN	56.63±0.72	53.19±3.27	4.56
ME(MJ/kg)	14.65^{b}±0.01	14.55^{a}±0.02	0.61

^{a,b}Means bearing different superscripts in a row differ significantly (P<0.05)

was apparent improvement (4.07%) in NDF digestibility in sheep fed micronutrient fertilized sorghum hay based diet, which corroborated with the findings of Sharma *et al*. (2004) who recorded an apparent improvement (ranging from 2.11 to 3.03%) in CF digestibility in lambs fed varying levels of mineral supplemented diet. This could be due to improvement in cellulose digesting bacteria growth by mineral supplementation (Zeleke *et al.* 2015). In contrast, Garg *et al.* (2008) reported significant improvement in digestibility of ADF and cellulose when supplemented 20 mg of organic Zn/kg DM, which suggested a positive role of organic Zn supplementation in fiber digestion. Similarly, Salama Ahmed *et al*. (2003) also reported increased digestibility of OM (P<0.07) and CP (P<0.01) in dairy goats supplemented with Zn-methionine in their diet. The DCP and ME intake of sheep in both the groups was similar as intake and digestibility of nutrients were comparable in both the groups and as per the requirement for maintenance of adult sheep (ICAR 2013). Shinde *et al*. (2013) also recorded comparable DCP and ME intake in lambs fed Cu and Zn supplemented diet. Mandal *et al*. (2007) and Jadhav (2005) also did not find any difference in the DCP and TDN intake in crossbred cattle calves and DCP intake in buffalo calves, respectively, on supplementation of Zn in their diet.

The apparent absorption and retention of N was positive

Table 3.Mineral intake, requirement and maximum tolerable level (ppm)

Particulars	Cu	Zn	Mn
Intake (mg/kg)	8.07–9.24	24.3–27.71	58.01–79.01
Requirement (mg/kg)	7–11	20–33	20–40
Maximum tolerable level (mg/kg)	25	750	1000

Table 4. Mineral intake and retention in experimental animals

Particulars	G1	G2	't' value
Zn intake (mg/d)	26.23^{a}±0.52	30.18^{b}±1.61	2.32
Excretion (mg/d)	14.51±0.77	14.72±1.43	0.13
Retention (mg/d)	11.72^{a}±0.66	15.46^{b}±0.89	3.34
Absorption coefficient (%)	44.73±0.02	51.63±0.03	1.79
Cu intake (mg/d)	8.71^{a}±0.15	10.06^{b}±0.51	2.50
Excretion (mg/d)	5.86±0.21	6.34±0.37	1.10
Retention (mg/d)	2.84^{a}±0.22	3.72^{b}±0.30	2.32
Absorption coefficient (%)	32.61±0.02	36.97±0.02	1.36
Mn intake (mg/d)	62.59^{a}±1.75	86.05^{b}±2.44	3.67
Excretion (mg/d)	36.40±1.61	45.77±1.99	1.91
Retention (mg/d)	26.19^{a}±1.23	40.28^{b}±2.25	4.03
Absorption coefficient (%)	41.91±0.03	47.12±0.02	1.48

^{a,b}Means bearing different superscripts in a row differ significantly (P<0.05).

and comparable between the groups. However, Kinal *et al*. (1996) have reported increased N retention with the increasing dietary concentration of Zn from 40 to 70 mg/kg DM in dry cows. But, similar to our findings Mandal *et al.* (2007) did not find any effect of Zn supplementation on N metabolism. It appears that there is a threshold level of Zn needed in the diet for optimum N metabolism; and supplementation above which has no further impact. The basal diet in the present experiment contained 32.72 mg Zn/kg DM, which might have been sufficient for optimum N metabolism in sheep. The retention of nitrogen expressed as a percent of nitrogen intake (23.59 vs 22.65%) and nitrogen absorbed (50.36 vs 46.52%) was also statistically nonsignificant between the groups.

The Zn, Cu and Mn content (mg/kg DM) in the diet of both the groups (Table 3) were as per the requirements recommended by NRC (1985) for sheep. The animals used in the experiment were adult type so the micronutrient requirement was met even from the untreated sorghum hay based diet, however, requirement for fast growing, lactating or pregnant animals will be more (Underwood and Shuttle 1999) and feeding of micronutrient fertilized fodder will be helpful in meeting the enhanced requirement for different productive stages of sheep. Cu, Zn and Mn intake was significantly (P<0.05) higher in sheep fed micronutrient fertilized sorghum hay based diet than control (Table 4). Similarly, Gowda *et al*. (2004b) also recorded significantly (P<0.05) higher intakes of Zn and Mn in cows supplemented with inorganic source of minerals. However, Sharma *et al*. (2004) did not find any variation in intake of micro-minerals in lambs supplemented with 10 and 20% higher minerals than in control. Excretion of Cu, Zn and Mn was comparable in both the groups as reported earlier by Gowda *et al*. (2004b) in crossbred dairy cows fed either mineral mixture supplemented or green fodder supplemented diet. Retention of Cu was significantly higher ($P<0.05$) in treated group which corroborated with the findings of Paul *et al*. (2010) in ewes supplemented with copper and zinc-methionine. In contrary to the present results, Khan (1978) observed reduction in Cu retention leading to negative Cu balance in cattle calves on supplementation of 30 and 60 mg Zn/kg DM to a basal diet containing 26 mg Zn/kg DM, but it may be due to very low level of Cu (5 mg/kg DM) in their basal diet. Attia *et al*. (1987) also reported decreased serum Cu levels due to supplementation of 250 and 1,000 mg Zn as ZnO in the basal diet of male buffalo calves. This may be due to very high levels of Zn supplementation, which might have an antagonistic effect on Cu absorption (Towers *et al*. 1981).

In respect of Zn and Mn metabolism, retention of Zn and Mn was significantly higher ($P<0.05$) in treated group than control. Similarly, Sharma *et al*. (2004) also recorded that daily retention of Zn increased linearly with the enhanced level of dietary Zn and supplementation of Mn improved its retention. In contrary to present findings, Mandal *et al*. (2007) and Fadayifar *et al*. (2012) reported nonsignificant effect on serum Zn and Cu concentration in lambs and steers due to supplementation of Cu or Zn in the diet. Absorption coefficient for Cu, Zn and Mn was non-significantly ($P>0.05$) higher in treated group than untreated group as reported earlier in lambs fed varying levels of mineral mixture (Sharma *et al*. 2004) and in cows with different levels of mineral intake (Gowda and Prasad 2005). Contrary to our findings, Garg *et al.* (2008) observed significantly ($P<0.05$) higher absorption coefficient for Zn in lambs with higher intake of dietary Zn.

Thus, it can be concluded that micro-nutrient (Cu, Zn and Mn) application to fodder sorghum improved the mineral content in the fodder. Subsequently, feeding of micronutrient fertilized sorghum hay based diet improved the intake and retention of micro-minerals significantly ($P<0.05$) without affecting nutrient intake, nutrient utilization and absorption coefficient of minerals in adult *Jalauni* sheep.

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