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Effect of feeding micro-nutrient fertilized oat hay based diets on nutrient utilization and mineral balance in growing lambs

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Abstract
Micro-nutrient deficiency in soil leads to inadequate availability of minerals in plant and animals. Thus, agronomic amendments have been advocated as short-term strategy for correction of this micro-nutrient deficiency in forages as well as in animals. To study the effect of feeding micro-nutrient enriched oat hay-based diet on nutrient intake and its utilization in lambs, twelve growing *Jalauni* male lambs (weighing 22.81±1.08 kg) were randomly divided into 2 groups of 6 animals in each. The lambs of control group (G_1) were fed on NPK fertilized chaffed oat hay *adlib* along with crushed barley grain (150 g/d/head) based ration, while the lambs of group G_2 were offered NPK+ fifty percent recommended dose of micronutrients (Zn, Mn and Cu 10, 5 and 2.5 kg/ha) + seed priming in 0.05% solution of $ZnSO_4$ for12 hours + VAM inoculated chaffed oat hay along with barley grain (150 g/d/head) for a period of 28 days. Micro-nutrient (Cu, Zn and Mn) application improved mineral content (ppm) in oat hay: Cu (7.88 vs 10.86), Zn (28.56 vs 34.22) and Mn (65.42 vs 83.70). The additional mineral supplementation through micronutrient enriched oat hay had no effect on DM intake in lambs. Similarly, the intakes of DCP, TDN and digestibility of DM, CP, NDF and ADF were also comparable between the groups. However, micronutrient (Zn, Cu and Mn) supplementation through fodder oat enhanced the mineral retention (Zn: 2.94 vs 4.47 mg/d; Cu: 0.46 vs 0.69 mg/d and Mn: 4.16 vs 5.83 mg/d) and absorption co-efficient was higher (P<0.05) in G_2 except for Mn which was non-significant The apparent absorption and retention of N was positive and comparable between the groups. Thus, it was concluded that micronutrient (Cu, Zn and Mn) application to fodder oat improved the mineral content in the fodder and feeding of micronutrient fortified oat hay based diet improved the intake and retention of micro minerals significantly (P<0.05) without affecting nutrient intake and utilization in growing *Jalauni* lambs.

Keywords: Fodder oat, *Jalauni* lambs, Micro-nutrient fertilization, Mineral retention, Nutrient utilization

Abbreviations: **ADF**: Acid detergent fiber; **CP**: Crude protein; **CPI**: Crude protein intake; **DCP**: Digestible crude protein; **DM**: Dry matter; **DMI**: Dry matter intake; **EE**: Ether extract; **NDF**: Neutral detergent fiber; **NFE**: Nitrogen free extract; **OM**: Organic matter; **TDN**: Total digestible nutrient; **TDNI**: Total digestible nutrient intake

Introduction
In Indian soils, the deficiencies of zinc (Zn), copper (Cu) and manganese (Mn) are to the tune of 49, 4 and 3% of soil samples, respectively (Devi *et al.,* 2014). Lactating and mature animals are undernourished and unable to meet their requirement of Ca, P, Cu and Zn from forages grown on these soils. Copper and zinc play an important role in various metabolic activities in animal system and a regular supply of these minerals in animals' diet is essential to maintain the normal growth, immunity, health and productivity (Haenlein, 2004). Zinc is an essential trace element for both animal as well as microorganisms present in the rumen, and is required for several metabolic functions (Eryavuz and Burk, 2009). Digestibility of dry matter (DM), organic matter (OM), and crude protein (CP) increased in goats when the diets were supplemented with 1 g/day organic Zn (Salama *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 region (Shinde and Sankhyan, 2007). In India, sheep mainly thrive on poor quality roughages, fallen tree 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 (Singh and Chouhan, 2017; Das *et al*., 2018) Hence, agronomic

amendment as short-term strategy was considered for correction of micronutrient deficiency in forages as well as in animals when fed micro-nutrients fortified forages. The present investigation was carried out to record the effects of feeding micro-nutrient fertilized oat hay based diet on nutrient utilization and mineral balance in growing lambs.

Materials and Methods

Study site and oat cultivation: Oat fodder was grown at Central Experimental Farm (25^0 27' N, 78^0 37' E and 275 m above mean sea level) of ICAR-Indian Grassland and Fodder Research Institute, Jhansi during *Rabi* season. The control oat fodder was grown with application of recommended dose of N, P, K, while the treated or micronutrient fortified oat fodder was grown with the application of NPK along with fifty percent recommended dose of micronutrients (Zn, Mn and Cu 10, 5 and 2.5 kg/ha) +Vesicular-arbuscular mycorrhiza (VAM) + seed priming (soaked for 12 hrs in 0.05% solution of $ZnSO_4$). Both the crops were managed following standard and recommended practices. The crop was then harvested at 100% flowering stage and dried in sun for hay making.

Experimental design: Twelve growing *Jalauni* male lambs (22.81 ±1.08 kg) were randomly divided into two groups of six animals each. In control group (G_1), the animals were fed NPK fertilized oat hay *adlibitum*, while the animals of G_2 group were fed micronutrient fertilized oat hay based diet. Both the groups were supplemented with crushed barley grain (@150 g/d/head) for a period of 28 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 an adaptation period of 21 days, a 7-day metabolism trial was conducted.

Sampling and analysis: For chemical analysis, pooled samples of feed offered, refusals and faeces were collected, dried at 60 ˚C and ground to pass 2 mm sieve. Wet faeces and urine samples, preserved in dilute sulphuric acid were used for N determination by the standard Micro Kjeldahl method. Feed and faeces samples were analyzed for proximate components (AOAC, 1995) and cell wall fractions (Goering and Van Soest, 1970). Zinc, copper, and manganese in feed, faeces and urine samples were determined for respective elements by using VARIAN AA240 Atomic Absorption Spectrophotometer. Data were analyzed to test the significant differences between means using 't' test as described by Snedecor and Cochran (1968).

Results and Discussion

Chemical composition of feed ingredients: Treated and untreated oat hays were analyzed for proximate composition, fiber fractions and micronutrient concentration (Table 1). Crude protein and fiber content in treated or untreated oat hay were comparable and similar with the earlier observations (Thomas *et al.* , 2013; Singh and Chauhan, 2017). Owing to the application of micronutrient, there was an increase in Zn, Cu and Mn concentration (16.54 %, 27.44 % and 21.84 %, respectively) in treated oat hay. Similar to present findings, Sahrawat *et al*. (2008), Ahmad *et al*. (2007) and Singh and Chauhan (2017) recorded higher Zn concentration in the straws of sorghum, maize, rice and oat 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.

Table 1. Chemical composition (% DM basis) of oat hay and barley grain

Attributes	Oat hay MNU	Oat hay MNF	Barley grain
OM	93.12	92.98	96.90
CP	7.58	7.82	12.25
EE	2.32	2.38	2.61
NDF	55.67	55.60	34.15
ADF	31.77	31.77	14.09
Zn (ppm)	28.56	34.22	30.98
Cu (ppm)	7.88	10.86	11.36
Mn (ppm)	65.42	83.70	58.88

MNU: Micro-nutrient unfertilized, MNF: Micro-nutrient fertilized

Intake and utilization of nutrients: Average daily DM intake (Table 2) was comparable between the groups. 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) when Zn was supplemented to a basal diet. Digestibility coefficient of DM, OM, and CP were comparable in lambs fed either treated (micronutrient fertilized) or untreated oat hay based diets. Mondal *et al*. (2004) observed no improvement in digestibility of DM and CP in *Black Bengal* goats when basal diet was supplemented with Cu and thus findings corroborated the results of present study. Mishra *et al*. (2016) also observed that the supplementation of micro-nutrient in the diet of cross-bred calves did not affect the intake and digestibility coefficients of different nutrients like CP, EE, NDF and ADF.There was an apparent improvement in the digestibility coefficient of NDF and ADF (3.21 and 2.89 units, respectively) in lambs fed micro-nutrient fertilized oat hay based diet, agreeing 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 diets. This might be due to the improvement in cellulose digesting bacterial 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 with 20 mg of organic Zn/kg DM, which suggested a positive role of organic Zn supplementation in fiber digestion. Average DCP and TDN intakes of lambs in both the groups were almost similar as intake and digestibility of nutrients were comparable in both the groups, and it was as per the requirement for maintenance of growing lambs (ICAR, 2013). Shinde *et al*. (2013) also recorded comparable DCP and TDN intakes in lambs fed Cu and Zn supplemented diet. Mandal *et al*. (2007) also did not find any difference in the DCP and TDN intake in crossbred calves on supplementation of Zn in their diets.

The apparent absorption and retention of N was positive and comparable between the groups. However, Kinal *et al*. (1996) 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 appeared that there is a critical level of Zn needed in the diet for optimum N metabolism, and supplementation above that level had no further impact. The basal diet in the present experiment contained 28.56 mg Zn/kg DM, which was probably adequate for optimum N metabolism in growing lambs. The retention of nitrogen expressed as a percent of nitrogen intake (27.08 vs 28.87 %) and nitrogen absorbed (43.71 vs 45.50%) was also statically non-significant between the groups.

Micronutrient retention and absorption coefficient: The animals used in the present experiment were in growing stage and the micro-nutrient requirement was met even

Table 2. Intake and utilization of nutrients in sheep fed micro-nutrient fertilized oat hay based diets

Attributes	Group G_1	Group G_2	't' value
Intakes			
Bwt. (kg)	22.71±1.02	22.9±61.16	0.18
DMI (g/d)	693.98±10.22	687.59±8.54	0.34
DMI (%)	3.11±0.12	3.02±0.15	0.36
DMI (g/kg $W^{0.75}$)	67.51±3.54	65.81±2.12	1.04
CPI (g/d)	59.32±0.14	60.21±0.16	0.36
CPI (g/kg $W^{0.75}$)	5.71±0.04	5.76±0.06	0.45
TDNI (g/d)	506.96±5.42	511.74±6.22	0.75
TDNI (g/kg $W^{0.75}$)	48.46±21.12	49.29±1.05	0.23
Digestibility coefficient (%)			
DM	62.98±0.99	64.51±1.02	0.62
OM	64.55±0.87	66.40±0.84	0.48
CP	60.92±0.75	61.66±0.78	0.64
NDF	50.84±1.04	51.05±1.00	0.32
ADF	42.87±0.82	42.76±0.86	0.44
EE	64.85±1.56	65.58±1.60	0.58
NFE	70.32±1.74	70.72±1.55	
N balance (g/d)			0.88
N intake	9.49±0.44	9.63±0.40	0.71
Faecal N	3.61±0.32	3.52±0.33	0.15
Urine N	3.31±0.30	3.10±0.26	1.03
N retained	2.57±0.24	2.78±0.22	0.96
N retained % of intake	27.08±1.65	28.87±1.44	0.45
N retained % of absorbed	43.71±1.88	45.50±1.55	0.54

G_1: Group fed micro-nutrient unfertilized oat hay, G_2: Group fed micro-nutrient fertilized oat hay

Table 3. Effect of micro-nutrient fertilized oat hay on mineral balance in sheep

Attributes	Group G_1	Group G_2	't' value
Zn intake* (mg/d)	20.18±0.32	23.01±0.36	3.06
Zn excreted (mg/d)	17.24±0.88	18.54±0.72	2.04
Zn retained* (mg/d)	2.94±0.54	4.47±0.45	2.84
Absorption coefficient* (%)	14.56±0.12	19.42±0.16	2.62
Cu intake* (mg/d)	5.98±0.15	7.53±0.24	5.02
Cu excreted (mg/d)	5.52±0.17	6.84±0.20	2.10
Cu retained* (mg/d)	0.46±0.11	0.69±0.14	4.70
Absorption coefficient* (%)	7.70±0.22	9.16±0.20	3.36
Mn intake* (mg/d)	44.44±1.12	53.81±1.24	3.99
Mn excreted(mg/d)	40.28±1.42	47.99±1.65	2.09
Mn retained* (mg/d)	4.16±0.12	5.83±0.24	2.31
Absorption coefficient (%)	9.35±0.58	10.82±0.72	1.99

G_1: Group fed micro-nutrient unfertilized oat hay, G_2: Group fed micronutrient fertilized oat hay; *(P<0.05)

from the untreated oat hay based diet. However, requirement for lactating or pregnant animals will be more (Underwood and Shuttle, 1999) and feeding of micro-nutrient fertilized fodder will be helpful in meeting the enhanced requirement for different productive stages of sheep. In the present study, the intake of Zn, Cu and Mn was significantly (P<0.05) higher (Table 3) in lambs fed micro-nutrient fertilized oat hay based diet (G_2) than control (G_1).This might be due to the higher concentration of micro-nutrients in fertilized oat hay. Likewise Gowda *et al*. (2004) also recorded significantly higher intakes of Zn and Mn in cows supplemented with inorganic source of minerals. Faecal and urinary excretion of Zn, Cu and Mn was comparable in both groups as reported earlier by Gowda *et al*. (2004) in crossbred dairy cows fed either mineral mixture supplemented or green fodder supplemented diets, while faecal excretion of Zn was lower in G_2 as compared to G_1. Retention of Zn, Cu and Mn was significantly higher (P<0.05) in micro-nutrient fertilized group than control group, which corroborated the findings of Paul *et al*. (2010) and Sharma *et al*. (2004) who also reported increase in retention of Zn and Mn with the enhanced level of dietary Zn and Mn. Apparent absorption is general indicator of the amount of nutrient absorbed from gastro intestinal tract. In this study, the absorption coefficient of Zn and Cu was significantly higher (P<0.05) in G_2 as compared to G_1. Similar to our findings, Garg *et al. (*2008) observed significantly (P<0.05) higher absorption coefficient for Zn and Cu in lambs with higher intake of dietary nutrients. But the absorption coefficient of Mn was non-significantly higher in G_2 when compared to G_1 as reported earlier by Sharma *et al*. (2004) in lambs fed varying levels of mineral mixture and Gowda and Prasad (2005) in cows fed different levels of mineral intake.

Conclusion

It was concluded that micro-nutrient (Cu, Zn and Mn) application to fodder oat improved the mineral content of the fodder. Subsequently, the feeding of micro-nutrient fertilized oat hay based diet significantly (P<0.05) improved the intake and retention of micro-minerals without affecting the intake and utilization of protein and energy in growing lambs. Hence, micronutrient fortified forages can be exploited for balanced rationing of livestock.

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