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Translocation of a Macro-Mineral from Soil Through Forage Plants to Goats Reared at Faisalabad, Pakistan

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Abstract: An experiment was conducted to determine the sodium status of goats during summer and winter seasons at Faisalabad, Pakistan. Forage plants, soil water and animal samples (milk, blood, urine and fecal) were gathered fortnightly for two months of summer and winter seasons of 2010-2011. The highest seasonal means of sodium in urine and blood plasma in male and non-lactating animals during summer season were 1080±6.11 and 1370±1.32 mg L^{-1}, respectively while in feces of lactating goats, it was 5.62±0.55 mg g^{-1} in the months of winter season. Similarly the highest seasonal means for milk, forages, soil, canal and tube well water were 730±1.33 mg kg^{-1}, 4.06±1.55 mg g^{-1}, 99±0.022 mg kg^{-1}, 69±4.11 mg kg^{-1} and 164±2.44 mg kg^{-1}, respectively. Results of the present study elaborated that sodium concentrations in feces, soils and forage plants were higher than critical levels, it was low in blood plasma and within the critical concentrations in urine and milk. Further studies are required to find out the exact requirement of minerals for the area under study for meat, milk productions and to cope with diseases in small ruminants.

Key words: Translocation · Goats · Sodium · Forages · Milk, Blood

INTRODUCTION

Pakistan is a land of different soils and agro-climatic regions. Most of the lands are comprised of arid or semiarid which are deficient of macro and micro-nutrients which are necessary for plant and animal's growth. Pakistan has severe deficiencies in mineral nutrients essential for animal growth and their better performance [1]. Deficiencies of minerals are the most limiting adversaries to all ruminants throughout the world [2]. Due to unurbanization livestock are limited only to small number of villages, therefore, causing shortage of milk and other products involving the ruminants [1]. Most plants and plant product contain relatively small amount of Na^+ in comparison to animal products. Most grains and vegetable protein concentrates are low in Na^+, containing 0.01-0.06%. Forages usually range form 0.007-0.12% Na^+. Prolonged deficiency of Na^+ causes loss of appetite, decreased growth, reduced milk production and loss of weight. Most of the animals can tolerate large quantities of dietary salt when and adequate supply of water is available [3]. The mineral imbalances in soil and forage cause impaired performance and abnormal growth in ruminants. Among all mineral nutrients potassium is one of them which is most effected by forage maturity [4]. The quality and quantity of mineral nutrients in foraged mainly depend upon factors like texture of soil, fertilization of the soils and irrigation water.

Sodium is absorbed in body as Na^+ ion and available to all parts whenever needed. Most of its amount is secreted through perspiration. It regulates the acid-base balance and blood volume. Insufficient amount of it may cause hypertension [3]. Therefore, it is necessarily added in the diets of ruminants. It causes hyponatraemia when its sufficient amount is secreted through vomiting, diarrhea and any kind of obstruction in digestive tract. Higher level of Na^+ in blood causes the hypernatraemia. Body of animals contains about 0.2% of Na^+ concentration. Sodium and Cl ions are absorbed from upper portion of small intestine and both are excreted in urine as salt. Its plays a basic role in nerve impulses, cell permeability and muscular functions [5]. This study was

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planned to assess the effect of summer and winter seasons on the translocation of sodium from forages to small ruminants and their excretion through urine and feces.

MATERIALS AND METHODS

Studies were conducted at local goat farm situated in Faisalabad between latitude 31° 24° N, longitude 73° 1° E and height above sea level 184 meters. Samples were by selecting lactating, non-lactating and male, four animals of each and clinically healthy taddi breed goats. Six samples were collected after the interval of each fortnight from all classes of animals, soil and waters. Soil samples were collected from six different sites of the study area then air dried, ground, thoroughly mixed and sieved for chemical analysis. Forage plant samples were gathered from the same site from where the soil samples were collected. Blood samples were collected from jugular vein by the disposable syringes. A pinch of anticoagulant ethylene-di-amine-tetra-acetic acid (EDTA) was added in it in order to avoid the clotting of blood sample. Samples were centrifuged (HERMLE, Z-233 M-2, abnet, Germany) at 3000 rpm for 20 minutes to separate the blood plasma. Morning and evening samples of milk were collected from lactating goats mix to make them uniform sample and stored in freezer at -20°C (SANYO, biochemical freezer, Model MDF-U333, Japan). Fecal, urine and water samples were collected at every fortnightly of animals mixed to form a uniform sample. Soil samples were processed with ammonium bicarbonate diethylene-triamine-pentaacetic acid (AB-DTPA) solution for soil analysis [6]. Ground and oven dried samples of forage plants and Fecal Matter was analyzed following the Wolf [7] and blood plasma by Mpofu *et al*. [8], while milk by following Stelwagen *et al.* [8]. Macronutrient was determined with flame photometer (Jenway, PFP-7) by using the standard curves and spectrophotometer. The data were analyzed using a split-plot design [10]. Differences among means were ranked using Duncan's new multiple ranges test [11].

RESULTS

In feces of lactating animals, the highest seasonal mean was 5.32 kg g^{-1} for summer season and 5.62 mg g-1 for winter season. In non-lactating animals it varied from 1.80 to 8.0 mg g^{-1} with mean 5.53 mg g^{-1} for summer season and ranged from 3.50 to 4.80 mg g^{-1} with mean 4.82 mg g^{-1} and for summer season varied from 3.50 to 7.0 mg g^{-1} with mean 4.82 mg g^{-1} for winter season. In male animals. sodium concentration varied from 3.61 to 8.0 mg g^{-1} with mean 4.86 mg g^{-1} in summer season. Sodium concentration of the fecal were significantly effected by fortnights at 0.05 and 0.01% levels while, remaining Goats, seasons and interactions among them did not affect significantly (Table III). In lactating animals the highest Na^+ levels in urine were 1068 mg L^{-1} during summer season and 690 mg L^{-1} for winter season whereas in non-lactating animals it remained 800 mg L^{-1} during summer season and varied from 719 to 1200 mg L^{-1} for winter season. In male animals its levels varied from 920 to 1200 mg L^{-1} with mean 1080 mg L^{-1} during summer season (Table I). Urine Na^+ concentration did not differ significantly in all three groups of goats and seasons. Fortnights had significant ($P<0.05$, 0.01) effects on urine Na^+ concentration. Coefficient of variance was greater than fecal and blood plasma (Table II).

In blood plasma of lactating animals its maximum contents in summer was 1290 and in the winter months was 1086 mg L^{-1}. Its levels in male animals ranged from 813 to 1380 mg L^{-1} with mean 1090 mg L^{-1} for summer season and from 110 to 910 mg L^{-1} with mean 908 mg L^{-1} for winter season. Its concentration found differing significantly ($P<0.05$, 0.01) in all classes of animals, fortnights and seasons ((Table I). Sodium concentration in blood plasma was significantly ($P<0.05$ and 0.01) affected by all animal classes, fortnights, seasons and interactions (A X FN, A X S, FN X S, A X FN X S) among them. Blood plasma had lowest coefficient of variance than fecal, urine and milk (Table II). Sodium concentrations in milk varied from 400 to 1200 mg L^{-1} with mean 730 mg L^{-1} during summer season and from 475 to 825 mg L^{-1} with mean 581 mg L-1 during winter season. Seasons, fortnights and their interactions exhibited significant ($P<0.05$, 0.01) effects on Na^+ concentration (Table III). In forage plants sodium concentration ranged from 3.50 to 4.21 mg $g^{-1}$and 3.62 to 4.25 mg g^{-1} with means 3.84 and 4.06 mg g^{-1} for summer and winter seasons respectively. Sampling periods (fortnights) and seasons had significant ($P<0.05$, 0.01) effects on its concentration (Table I).

Sodium concentration in soil showed significant ($P<0.01$) variations during both seasons (Table I). In soils sodium levels ranged from 60 to 130 mg kg^{-1} for summer and from 70 to 120 mg kg^{-1} in winter season (Table III). Seasons and fortnights had significant ($P<0.01$) effects on its concentration. Sodium concentration of soil, forage plants, tube well water and canal water were significantly $P<0.01$) affected by seasons, fortnights except canal water which was not significantly affected by the seasons

Table 1: Sodium concentrations of different samples of feces, urine, blood, milk, forages, soil and water at different fortnights during summer and winter seasons.

Animal types	Sample type	Seasons	Sampling periods (fortnights) I	II	III	IV	Seasonal means
Lactating	Fecesmg g^{-1}	Summer	3.50±0.21	6.00±0.02	7.00±0.21	4.78±0.002	5.32±0.002[a]
		Winter	3.50±0.54	4.00±0.36	7.00±0.65	8.00±0.36	5.62±0.55[a]
Non-lactating		Summer	5.00±0.87	7.34±1.25	8.00±0.32	1.80±.058	5.53±0.22[a]
		Winter	4.00±0.32	3.50±0.36	4.80±0.65	7.00±0.001	4.82±3.00[a]
Male		Summer	4.11±0.56	3.61±0.47	3.72±0.9	8.00±0.36	4.86±1.22[a]
		Winter	6.00±0.23	5.00±0.36	4.81±0.54	3.50±0.25	4.82±1.44[a]
Lactating	Urinemg kg^{-1}	Summer	1800±0.56	700±5.47	875±0.36	900±6.45	1068±5.44[b]
		Winter	112±0.89	900±6.58	1050±0.22	700±4.65	690±6.11[a]
Non-lactating		Summer	800±0.21	800±3.58	800±0.55	800±7.98	800±3.00[a]
		Winter	900±0.54	719±3.41	1100±0.11	1200±3.54	979±4.00[a]
Male		Summer	1200±0.54	1100±6.5	1100±0.32	920±3.12	1080±6.11[b]
		Winter	700±0.65	800±3.12	1100±0.54	1200±6.54	950±5.66[a]
Lactating	Plasmamg kg^{-1}	Summer	812±0.32	910±6.45	2600±0.54	840±4	1290±4.88[a]
		Winter	700±0.31	1225±9.7	1319±0.87	1100±56	1086±2.66[b]
Non-lactating		Summer	954±0.54	1658±3.1	2510±0.54	360±7	1370±1.32[a]
		Winter	812±0.54	920±6.54	1250±0.65	1319±89	1075±6.66[b]
Male		Summer	813±0.87	920±8.79	1250±3.21	1380±1	1090±2.11[b]
		Winter	110±2.21	812±6.54	812±2.65	910±56	908±4.55[c]
Lactating	Milkmg kg^{-1}	Summer	620±3.21	400±1.58	700±5.54	1200±8.77	730±1.33[a]
		Winter	825±4.56	525±2.58	500±4.58	475±6.66	581±2.55[b]
	Forage mg g^{-1}	Summer	3.50±0.25	4.00±0.25	4.21±0.25	3.68±5.44	3.84±1.00[b]
		Winter	4.18±1.25	3.62±0.00	4.20±0.54	4.25±1.001	4.06±1.55[a]
	Soil mg kg^{-1}	Summer	60±1.32	62±3.11	80±0.55	130±3.54	83±1.88[b]
		Winter	110±0.21	99±2.66	120±0.66	70±6.99	99±0.022[a]
	Canal water	Summer	39±0.54	81±1.44	76±1.54	81±1.55	69±4.11[a]
	mg kg^{-1}	Winter	62±0.32	39±3.11	85±0.21	54±1.004	60±1.00[b]
	Tube well	Summer	130±4.21	139±6.44	150±2.14	200±6.55	154.7±4.00[b]
	water (mg kg^{-1})	Winter	170±1.36	139±3.21	140±0.54	210±3.22	164.7±2.44[a]

For respective parameter similar alphabets in columns do not differ significantly (p>0.01)

Table 2: Analysis of Variance (ANOVA) of Na^+ concentration in fecal, urine, blood plasma and milk at different fortnights during summer and winter seasons.

SOV	df	Mean Sum of Squares for sodium FEM	URIN	PLSM
Animal (A)	2	74583.00[NS]	2.08[NS]	2346.06[*, **]
Fortnight				
(FN)	3	209555.02[*, **]	12366.667[*, **]	14995.08[*, **]
A X FN				
Season (S)	6	20161.690[NS]	2.08[NS]	3550.55[*, **]
A X S				
FN X S	1	2920.083[NS]	1008.33[NS]	6276.75[*, **]
A X FN X S				
Error	2	530.0830[NS]	3502.083[NS]	164.18[*, **]
	3	27749.472[NS]	786.11[NS]	8593.55[*, **]
	6	21889.472[NS]	3279.33[NS]	3936.88[*, **]
	24	17129.625	2443.58	170.33
Total	47	65874258.99	5877724.84	853597.65

Table 2: Continuee

SOV	df	Mean Sum of Squares for sodium		
		FEM	URIN	PLSM
CV (%)	24.45	59.79	1.14	
SD	345	24	514	
Milk				
SOV	df	Mean Sum of Squares for Na^+		
S	1	91809*, **		
FN	3	102965.75*, **		
SXFN	3	180615.833*, **		
Error	8	152.500		
Total	15	8543987.687		
CV (%)	1.87			
SD	250			

*' ** ± Significance at 0.05, 0.01 levels, respectively; A, animal; S, season; FN, fortnight; CV, coefficient of variation; $ó^2$, variance; SD, standard deviation.

Table 3: Analysis of variance (ANOVA) of data for Na^+ concentration in soil, forage, tube well water and milk at different fortnights during summer and winter seasons.

SOV	df	Mean Sum of Squares for Na^+			
		SOIL	FORG	TUWW	CANW
S	1	1072.563*,**	184255.563*,**	39.063*,**	64.00[NS]
FN	3	395.729*,**	300984.063*,**	3542.729*,**	554.167*,**
SXFN	3	2169.729*,**	252331.563*,**	440.063*,**	921.833*,**
Error					
	8	12.688	0.063	11.438	11.125
Total	15	5647.35	84532588.65	3258.147	58682.54
C.V. (%)	3.88	0.01	2.13	5.40	
S.D.	6.082	74.00	7.00	4.369	

*' **, Significance at 0.05, 0.01 levels, respectively; NS, non-significance; FORG, forage; TUWW, tube well water; CANW, canal water. CV, coefficient of variation; $ó^2$, variance; SD

(Table III). In tube well water its maximum levels during summer and winter were 154.7 mg L^{-1} and 164.7 mg L^{-1}, respectively. (Table I).

DISCUSSION

The maintenance of soil fertility depends on continuous incorporation and transformation of organic matter into soil. Nutrients present in soil only become available to plants when certain essential conditions are satisfied [6]. Assessment of minerals status of animals mainly influenced by the plant components consumed and soil types of the area upon which plants are grown [12]. The results of present study evaluated for summer season were lower than evaluated by Little [13] who found 1-4 g kg^{-1} for dietary requirements for ruminants. Mostly grains and vegetable protein concentrates contain low Na^+ usually 0.01-0.06%. Forages usually contain about 0.007-0.12% of Na^+. Forage species in Florida were analyzed and determined that all samples were deficient of Na^+ concentrations. In recent study, low levels of Na^+ in forage plants during summer season may be depressed by high levels of K^+ contents [14]. Its lower levels in some fortnights might be due to the harsh conditions in the summer seasons [15]. Khan *et al*. [4] also, reported 400-700 mg/kg Na^+ forage plants and in feed samples 11700-1200 mg/kg during summer and winter seasons, respectively. In most of the tropical countries naturally occurring forages usually contain low contents of Na^+ over the world [14]. Water is required for photosynthesis, serves as reagent enabling biological reactions to occur and directly influence plant root respiration, oxidation-reduction potential of the soil and activities of soil microorganisms [6]. Total soluble salts (T.D.S.) ranged 1.0-2.9 g L^{-1} in drinking water are considered satisfactory for grazing ruminants. However, more than 10.0 g L^{-1} can not be recommended for animal [3]. Generally, the canal and tube well waters may contain higher levels of contaminated minerals that indirectly contribute towards availability to plants. Evaluated concentrations of sodium in feces were much higher than values observed by Khan *et al*. [2] who observed 18-28 mg L^{-1} in canal water. In the present work, on the contrary, greater amount of Na^+ was excreted through fecal than urine. It may be due to the estimation error or due to involvement of some other physiological processes. These results were in close agreement as found by Khan *et al*. [4] who observed 0.9-1.0 g kg^{-1}. Pasha *et al*. [16] evaluated 114-128 m Eq L^{-1} Na^{+} in blood plasma of adult goats during summer and winter seasons. Interrelationships of mineral nutrients among forage plants, soil types and animals under study could provide the precise profile of blood plasma mineral contents in the developing world [12]. The results of present study were very similar to findings of the Khan *et al*. [4] who found 2.0-2.2 g L^{-1}.

It was concluded from this study that sodium concentrations in feces, soils and forage plants were higher than critical levels while in blood plasma were lower than critical concentrations. Its concentrations in urine and milk found within the critical concentrations. In future further studied will be required to explore the relationship of Na^{+} with other mineral nutrients for milk and meat production from farm animals.

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