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Determination of Variability in Potassium Contents in Goats During Winter and Summer Seasons Reared at a Private Farm in Faisalabad, Pakistan

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Abstract: An experiment was conducted to determine the potassium status in goats during summer and winter seasons at Faisalabad. Forage, soil water and animal samples (milk, blood, urine and fecal matter) were gathered fortnightly for two months of summer and winter seasons. Through feces the highest potassium concentration (9.5±0.025 mg g^{-1}) excreted in males during winter, while the lowest (7.01±0.25 mg g^{-1}) in non-lactating goats during summer. Similarly the highest amount (1193±3.74 mg kg^{-1}) of it excreted through urine in males whereas the lowest (696±2.54 mg kg^{-1}) in lactating animals in the months of summer season. Overall it's the highest levels (507±5.11 mg kg^{-1}) found in non-lactating during winter whereas in milk observed (5.49±3.69 mg kg^{-1}) in the months of summer season. Forages and tube well water contained 13.31±3.95 mg g^{-1} and 8.5±0.01 mg kg^{-1}, respectively in the summer while soils and canal water had 15.5±0.65 mg kg^{-1} and 4.3±0.44 mg kg^{-1}, respectively during sampling in winter. It was concluded that K^+ concentrations in fecal matters were within the critical levels. Blood plasma, forage plants and canal waters showed higher contents than reference values where as urine, milk and soils showed the lower limits than ruminant requirements. Supplementation of potassium was recommended for better growth, reproduction, milk and meat p roduction under the experimental area.

Key words: Potassium · Milk · Blood · Urine · Feces · Goats

INTRODUCTION

In plants, potassium deficiency causes the reduced plant growth, lessening seed and fruit quantity, curling and burning of leaf margins. High K^+ content in forages during critical times of the year can be antagonistic to Mg^{2+} absorption/ or utilization and thus can influence the incidence of grass-tetany in ruminants. Mineral nutrients decline as plants mature due to the dilution and their translocation to plant root system [1]. It acts as cofactor in protein synthesis, as a solute in water balance and affecting process of osmosis and proper functioning of stomata in plants [2]. Most of the forage samples were sufficient in Na^+, P, K^+, Ca^{2+} and Mg^{2+} for the requirements of ruminants grazing in the soon valley [3]. In Asia, most of the livestock are used to fed on crop residues and fodders, commonly, grown on wastelands [4]. Forages are deficient of K^+ in most areas of Pakistan. Among all mineral nutrients potassium is one of them which is most effected by the forage maturity [5, 6]. Clinical signs disappear after supplementation of potassium [5]. Mainly K^+ is absorbed by simple diffusion from the upper small intestine, but some absorption also occurs in lower small intestine and large intestine [7]. Sodium, K^+ and Mg^{2+} are basic component in maintaining the phenomenon of osmo-regulation between cells and intestine. Excitation causes the urinary loss of K^+ further more other disturbances like fever and diarrhea enhances its loss. Fecal loss accounts for only about 13% of total loss of K^+ in cows, with the remainder being excreted in the urine. In sheep, considerable K^+ is present on the skin and in the fleece [8]. It is a basic cation in intracellular fluid and regulates the acid-base balance and contraction of cardiac muscles. In forage crops K^+ is affected by plant maturity, species as well as variety within a species, management procedures such as grazing or crop removal systems and environmental conditions [9]. Stage of maturity is probably the most important factor influencing K^+ concentrations in forage plants.

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Hypokalaemia (lower level of serum K^+) in lactating cows lowered the milk production. Hyperkalaemia (increased level of serum K^+) occurs in renal failure, shock and dehydration. Its symptoms are dilation of heart, irregularities in cardiac muscles and ulceration of small bowel. Progesterone and 17 beta-estradiol hormones are excreted during the ovulation and their concentrations are directly proportional in the milk and blood. Lactating cows have higher K^+ requirement because due to high milk production and high milk contents. Potassium contents in human and goat milk are very similar whereas lower as compared to cow milk. It also plays a very important role in the acid base balance and transportation of the carbon dioxide through the blood. Potassium deficiency results in nonspecific signs such as slow growth, reduced feed and water intake, muscular weakness and nervous disorders in ruminants [10]. Adverse effects on secretions were strongly related to a change in the Na^+/ K^+ ratio because reduction in ratio also reduced the milk secretion [11]. Infertility, non-infectious abortions, anemia and bone abnormalities are some of the clinical signs suggested mineral deficiencies in the livestock [9, 12]. The purpose of the work was to determine the mineral level in soil, forage, water and its status in blood, urine, fecal matter and milk for proper nourishment of livestock.

MATERIALS AND METHODS

Studies were carried out at local goat farm at Faisalabad by selecting, five each, lactating, non-lactating and male healthy goats. Ten samples were collected after interval of each fortnight from all classes of animals, soil, forage plants and waters. All experimental goats remained same throughout study period. Soil samples were collected dried (THELCO, model 6, Germany) and sieved through 0.2 mm mesh for chemical analysis [13]. Water samples from tube well, canal and tap were collected from where goats drank. Samples were collected in plastic bottles (100 ml) and stored at -20°C for further analysis. Forage plant samples were gathered from same site from where the soil samples were collected. Fecal matter samples were collected twice a daily at every fortnight from all types of animals under study. Samples were mixed to form a uniform sample. Samples were collected in polyethylene bags and stored at -20°C (SANYO, biochemical freezer, Model MDF-U333, Japan). Ground and oven dried samples were processed for further analysis [14]. Blood samples were collected from jugular vein by disposable syringes. A pinch of anticoagulant (EDTA) was added in it in order to avoid clotting of blood sample. Samples were centrifuged (HERMLE, Z-233 M-2, abnet, Germany) at 3000 rpm for 20 minutes to separate blood plasma and further processed following the methods of Mpofu *et al*. [15]. Morning and evening samples of milk were collected from lactating goats mix to make them uniform sample. One ml of $K_2Cr_2O_7$ (30%) added in them as preservative analyzed for the determination of potassium [16]. The results obtained were analyzed [17] and differences for data were checked at 0.01 probability levels [18].

RESULTS AND DISCUSSION

Forage Plants: Potassium is vital to several plant processes and adequate K^+ activates at least 60 enzymes; maintains an appropriate rate of photosynthesis, transportation of its byproducts and facilitates protein synthesis. Fast growing grasses and legumes have higher amounts of K^+. Commonly used grains may have lesser amounts of K^+ [19]. Generally, most forage has more K^+ than required by ruminants. Random patterns in the potassium levels for forage plants were recorded for both seasons. Highest value of 16.0±0.58 mg g^{-1} was found for 4th fortnight of summer season. Their seasonal means were 13.31±3.95 and 11.67 mg g^{-1} for both seasons respectively. There was significant effect ($P<0.05$) of seasons and fortnights on forage K^+. Forage K^+ was highest at 4th fortnight of summer season. The evaluated values in forage plants were in close agreement with the findings of Khan *et al.* [6] who determined 16-21 g kg-1 in feed offered to ruminants. Whereas, in literature [19] 0.80% forage K^+ for ruminant requirements is recommended. McDowell, [9] in his experiments found 0.80% K^+ in the forage plants essential for grazing ruminants. The great amount of K^+ is absorbed by simple diffusion from the upper part of small intestine and some portion through large intestine. About 13% of total loss of K^+ is excreted through fecal matter while remaining by urine. About, 30% of K^+ is excreted through the skin in sheep in hot and humid conditions [10].

Soil and Waters: An average crop receives more quantity of K^+ from soil than more or often applied in the form of K^+ fertilizer. Seasonal means of potassium in soils were 11.0±0.55 and 15.5±0.65 mg kg^{-1} for summer and winter seasons. Inconsistent patters were observed for summer samplings but for winter season its levels increased from 1st to 4th fortnight. Increasing trends in K^+ of soils were found during winter season while it was decreasing for tube well water during both seasons. Its highest value was recorded at 2nd fortnight (21.0 ± 0.69 mg kg^{-1}). Highest K^+ levels in canal water were recorded at 1st fortnight and consistently decreased to 4th fortnight for summer season. Their seasonal means were 4.3 ± 0.22 and 3.4 ± 0.44 mg kg for summer and winter seasons. In tube well water highest value recorded was 10.0 ± 0.54 at 1st fortnight of summer season. Its seasonal means were 8.5 ± 0.01 to 7.75 ± 2.0 mg kg^{-1} in summer and winter seasons respectively. Statistically significant ($p<0.01$) effects for seasons, fortnights and interactions(S X FN) were found for K^+ levels in soil samples. In the present study soil K^+ differ significantly in both seasons during the all sampling periods. Soil K^+ abruptly increase from 1st to 2nd fortnight in the months of summer. Ashraf *et al.* [20] evaluated 60-250 mg kg^{-1} K^+ concentrations in the soils, while Underwood [21] suggested 8.0 g kg^{-1} critical concentrations of K^+ in soils for ruminant requirements. Tube well and canal waters also showed significant variation ($P<0.01$) for K^+ during seasons and fortnights but in canal water variations in K^+ did not significance in case of seasons. Evaluated values were lower than values of 12-20 mg L^{-1} in canal water determined by Ashraf *et al.* [20]. On the contrary Khan *et al*. [6] reported 4-6 mg L^{-1} of potassium in tube well water.

Feces and Urine: Inconsistent patterns of K^+ in feces of all types of animals were observed for all fortnights of both seasons except for fortnightly sampling periods during winter season in lactating goats. Its highest levels were observed at 3rd fortnight of winter season in male goats. Their seasonal means were 7.01 ± 0.25 to 9.50 ± 0.25 mg g^{-1} for summer and winter seasons. Potassium concentration of fecal matter were not significantly affected by animal classes, fortnights, seasons and 1st and 2nd order interactions among them except to that of animals and fortnights in which K^+ concentration showed statistical significant variations ($P<0.05$). Potassium concentration of feces of lactating and non-lactating goats exhibited great variations during both seasons. The observed K^+ concentrations in feces were similar with values of 7-7.5 g kg^{-1} found by Khan *et al.* [6] in sheep. In a research article.

Govenlock *et al*. [22] evaluated 1.0-3.0 g kg^{-1} critical concentrations of potassium for adult and kids of goats. Ruminants require 0.5-1.0% and lactating dairy cows 1.2% of potassium. Excitation tends to increase K^+ loss through urine and further loss is increased by fever and diarrhea. Higher amounts of K^+ are lost by vomiting, diarrhea and diuretics. Inconsistent patterns of K^+ in urines were found in all types of animals except in summer season for non-lactating animals. Its highest levels of K^+ were recorded at 3rd fortnight of winter season in lactating goats. Seasonal means for urine K^+ ranged from 696 ± 2.54 to 1193 ± 3.74 mg L^{-1} for both seasons during seasons of summer and winter respectively. Potassium concentrations in urine were affected ($P<0.01$) by animals, seasons, fortnight and 1st and 2nd order interactions. All K^+ concentration evaluated in urine samples were much lower than values of reported by Khan *et al*. [6] reported 2.5-2.8 g L^{-1} in sheep and by Ashraf *et al.* [20] who found 7.0-8.50 g L^{-1} in urine of lactating buffaloes.

Blood Plasma: Potassium is a constituent of blood cells and tissues which plays a vital role in the regulation of acid-base balance in body. Potassium transport oxygen and carbon dioxide through blood and carry's about half of the blood's carbon dioxide. Potassium performs same function in plasma and intestinal fluids as Na^+ inside the cells. It is major intracellular cation, provides about 75% of total cations of the body [10]. Seasonal means of blood plasma K^+ in all animals ranged from 448 ± 1.25 to 476 ± 4.21 mg L^{-1} for both seasons. Its highest concentration (375 ± 2.13 mg L^{-1}) was recorded at 1st fortnight of summer season in male animals. Potassium concentrations in blood plasma were affected ($P<0.01$) by animals, seasons, fortnight and 1st and 2nd order interactions. Recent results of K^+ levels in plasma were much lower (100-250 mg L^{-1}) than already reported by the Khan *et al*. [6] in sheep reared at an experimental station. Miles *et al.* [23] mentioned critical levels of 200 mg L^{-1} of plasma potassium in sheep whereas, Ashraf *et al.* [20] reported 1.00 g L^{-1} of K^+ concentration in blood plasma of buffaloes.

Milk: Potassium requirement for goats and sheep of all classes are the 0.50-0.80% (Anonymous, 1985b). it is evident that on live weight bases goats are the best milk producers than other livestock [24]. Milk contains about 15% of K^+ as compared to 0.11% Ca and 0.08% phosphorus. Milk is the major source of K^+ for all species. Lactating cows have higher dietary requirements of K^+. Potassium lost by cow's amounts to 1.50 g L^{-1} milk. Potassium deficiency in ruminants causes the slow growth, muscular weakness, nervous disorders, stiffness and emaciation [1]. Excessive K^+ interferes with Mg^{2+} and P absorption. Hence both minerals may increase the occurrence of urinary calculi in animals. Random patterns of K^+ in milk of lactating animals were observed for both seasons. Its highest levels were found at 2nd fortnight during summer season.

Table 1: Potassium concentrations (mean±SE) in forage plants, soil, canal and tube well waters and in feces, urine, milk and blood plasma of lactating, non-lactating and male goats during different fortnights of summer and winter seasons

	Animal types					
	Lactating		Non-lactating		Male	
	Seasons					
Sample types	Summer	Winter	Summer	Winter	Summer	Winter
Feces mg g^{-1}	7.50±0.54bc	8.24±0.44b	7.01±0.25c	8.31±0.63b	8.08±0.44b	9.50±0.25a
Urine mg L^{-1}	696±2.54de	990±8.44bc	943±6.99bc	1071±5.47b	1193±3.74a	793±6.58d
Plasma mg L^{-1}	448±1.25b	454±3.54b	492±0.22a	507±5.11a	411±3.11d	476±4.21bc
Milk mg L^{-1}	549±3.69a	529±4.21b	-	-	-	-

	Seasons	
Sample types	Summer	Winter
Forages mg g^{-1}	13.31±3.95b	11.67±0.54a
Soil mg kg^{-1}	11.5±0.55b	15.50±0.65a
Canal water mg L^{-1}	4.43±0.22a	4.30±0.44b
Tubewell water mg L^{-1}	8.5±0.01a	7.75±2.00b

Letters followed by similar superscripts did not differ significantly (p>0.01)

Table 2: Analysis of variance (ANOVA) of data for K^+ concentration in fecal matter, urine, blood plasma and milk at different fortnights during summer and winter seasons

		Mean Sum of Squares for K^+		
SOV	df	Fecal matters	Urine	Blood Plasma
Animal (A)	2	318595.6880^{NS}	2763.390**	16698.771**
Fortnight (FN)	3	102598.97^{NS}	1198.96**	3695.790***
AXFN	6	31670.743*	1168.84**	7625.750**
Season (S)	1	43391.333^{NS}	157.680**	5568.510**
AXS	2	8013.3960^{NS}	8962.56**	2547.860*
FNXS	3	21468.222^{NS}	1177.91**	21699.62*
AXFNXS	6	46652.785^{NS}	601.785**	7361.170*
Error	24	45762.208	14.5630	249.6040
Total	47	4258777.45	2545884.587	658474.2
C.V.(%)	26.34	5.34	4.38	

Milk

SOV	df	Mean Sum of Squares for K^+
S	1	36005.063**
FN	3	41195.229**
SXFN	3	79698.229**
Error	8	0.688
Total	15	96532484.21
C.V. (%)		0.17

*’ ** ± Significance at 0.05, 0.01 levels, respectively; A, animal; S, season; FN, fortnight; CV, coefficient of variation

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

		Mean Sum of Squares for K^+			
SOV	df	Soils	Forages	Tube well water	Canal water
S	1	49.00**	333625.0**	3.516^{NS}	0.016^{NS}
FN	3	43.833**	488991.667*	2.182^{NS}	9.711^{NS}
SXFN	3	67.167**	26005.000^{NS}	0.932^{NS}	1.272^{NS}
Error	8	0.875	56500	0.203	0.126
Total	15	21.06			
C.V. (%)	6.80	21.06	5.48	8.43	

*’ **± Significance at 0.05, 0.01 levels, respectively; NS, non-significance; C.V. (%), coefficient of variation

Their seasonal means were 549±3.69 to 529±4.21 mg L^{-1} during summer and winter seasons respectively. Similar concentration of K^+ in milk has already been reported by the Govenlock *et al.* [22] who evaluated critical levels of 350-700 mg L^{-1} for goats and sheep. The recent levels of K^+ in milk were found much lower than levels of 1.0-1.3 g L^{-1} in sheep reported by Khan *et al*. [6] and Underwood [21] who determined critical levels of 1.5 g L^{-1} for ruminants. Ashraf *et al.* [20] found 1.0 g L^{-1} of potassium in the milk of lactating buffaloes.

CONCLUSION

It was concluded that levels of potassium in blood plasma, forage plants and canal waters were sufficient for the normal growth and developments of under study ruminants. On the contrary, urine, milk and soil depicted lower concentrations of potassium. Although the potassium contents of forage plants were higher but soil samples displayed its deficiency. For better reproductive potential and development of the ruminants, the soils which are the main source of nutrients for plants, supplementation of the potassium was recommended through feed or fertilization of forage plants.

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