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MINERAL COMPOSITION OF SOME RANGE GRASSES AND SHRUBS FROM HARBOI RANGELAND KALAT, PAKISTAN

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Abstract

The mineral composition including K, P, Cu, Mn, Fe and Zn of some grasses and shrubs from Harboi rangeland, Kalat, Balochistan was analysed at three phenological stages. There were non-significant differences between grasses and shrubs in K, P, Fe and Zn contents. The concentration of Cu was higher in shrubs than grasses while Mn was higher in grasses than shrubs. The differences in the K, P, Mn, Fe and Zn were insignificant among the various phenological stages. Generally K and Fe were sufficient while P and Zn were deficient in most of the analysed forage plants. The concentration of Cu was mostly within the toxic range for livestock. The mineral concentration of forage plants generally increased/ decreased inconsistently with the advancing phenological growth stages in most plants. Across all the grazing seasons the forage for sheep and goats was generally deficient in one or other mineral at some stage for growth and maintenance. It is concluded that the poor livestock productivity in Harboi rangeland is partially due to insufficient amount of mineral efficient forage. It is suggested that fertilization of soil and vegetation with additional source of commercial fertilizers will not only improve the over all vegetation cover but also improve the health and productivity of grazing animals and other wild life in this rangeland.

Introduction

Rangelands in Pakistan support 30 m herds of livestock that contribute about 400 m US $ to national earnings (Anon., 2006). Range animal productivity depends on the efficiency of livestock to properly utilize range forage. Minerals are essential not only for the normal growth and development of plants but also for the growth, maintenance and productivity of grazing livestock in rangelands. The mineral composition of range plants is influenced by various environmental factors including geographic aspects, climate, soil minerals and grazing stress, seasonal changes, phenological stages, available palatable species and ability of plant to uptake minerals from soil and digest in its body (Cook & Harris, 1967; Malik & Khan, 1965, 1966, 1967, 1971; Kalmbacher & Martin, 1981; Kalmbacher, 1983; Hart *et al.*, 1983; Murray, 1984; Meyer & Brown, 1985; Pinchak *et al.*, 1990; Fierro & Bryant, 1990; Wahid, 1990; Liu, 1993; Robles & Boza, 1993; Ganskopp & Bohnert, 2003; Khan *et al.*, 2004, 2005, 2006). Rehman & Mackintosh (1996) reported that potassium contents adversely affect the preference of sheep for plants as it prefers potassium rich species. It is obvious that mineral composition not only affects the palatability of species but also reduces health growth, productivity and reproductive capacity of grazing animals. Razic *et al.*, (2003) stated that Zn, Fe and Mn are important immunostimulant which strongly affect the biological activity in living system. Studies have concluded that poor animal health, productivity and reproductive problems are common even in the presence of sufficient quantity of forage because of mineral deficiencies (Yousseff *et al.*, 1999; Tiffany *et al.*, 2000). Ganskopp & Bohnert (2003) reported that mineral composition of grasses changed seasonally especially with dry climate. Natural forage provides essential minerals to grazing livestock. In most cases the constraints in the productivity of grazing livestock is related to excess or deficiency of minerals. More than 90% of the area of Balochistan is classified as rangeland that provides more than 47% of the total sheep population to other parts of Pakistan. Furthermore, grazing animals get more than 90% of their forage and nutritional requirement from these natural rangelands (Rasool *et al*., 2005). It is therefore important to understand the mineral composition of forage plants in natural rangelands. Some studies made on Harboi rangeland (Durrani *et al*., 2005; Durrani & Hussain, 2005; Hussain & Durrani, 2007, 2008a,b) concluded that these rangelands are generally not only deficient in quantity but also poor in nutritional quality of available forage. As no such information on the mineral composition of plants of this rangeland is available, therefore the objective of the present study was to evaluate the mineral status of some forage plants in relation to goats and sheep in Harboi rangeland. The findings will help stockmen and range managers for improving the productivity of livestock.

Materials and Methods

The location, climatic, floristic and other ecological characteristics of Harboi rangeland have been provided in details in our previous papers (Durrani *et al*., 2005; Durrani & Hussain, 2005, Hussain & Durrani, 2007).

Collection of plant samples: Plant samples of six shrubs and four grasses (Table 1), collected at three phenological stages (seedling/pre reproductive, flowering/reproductive and post reproductive) from Harboi rangeland, were oven dried at 65^{o}C for 72 h. The dried powdered samples were stored in plastic bags for all further analysis.

Phosphorous contents were determined by spectrophotometric analysis using spectronic-20. Potassium contents were measured at 766.5 nm copper at 324.7 nm, manganese at 279.5 nm, zinc at 213.9 nm and iron at 248.3 nm using computerised atomic adsorption spectrophotometer following standard procedures (Anon., 1982, 1990; Galyean, 1985)

Statistical analysis: For the comparison of chemical contents of grasses and shrubs t-test was applied. While for the comparison of chemical contents among phenological stages and among grasses and shrubs, randomized block design was used (Steel *et al*., 1997).

Results and Discussion

Chemical composition of range vegetation is highly heterogeneous and dynamic across space and time. Late winter or early spring lambing/kidding is a common practice on rangelands of Balochistan and this coincides with the commencement of rapid spring growth of vegetation. The forage in this period is generally considered quantitatively and nutritionally sufficient for physiological requirements of sheep and goats. The maintenance period of animal is from June to September and this is the time when these rangelands become deficient in required quantity and quality of forage. It was observed that a great diversity in mineral contents of analysed plants from Harboi range existed in different plant species at various phenological stages (Tables 2 & 3). The results are discussed below.

Table1. Palatability of plants with their phenological stage used for chemical analysis.

	Species	Palatability at		
		Pre reproductive	Reproductive (Flowering)	Post reproductive (post fruiting)
	Shrubs			
1.	*Artemisia maritima* L.	Highly palatable	Highly palatable	Highly palatable
2.	*Perovskia abrotanoides* Karel	Rarely palatable	Highly palatable	Highly palatable
3.	*Perovskia atriplicifolia* Bth.	Rarely palatable	Highly palatable	Highly palatable
4.	*Convolvulus leiocalycinus* Boiss.	Highly palatable	Highly palatable	Highly palatable
5.	*Sophora griffithii* Stocks	Non palatable	Shoots non- palatable/ pods moderately palatable	Highly palatable
6.	*Hertia intermedia* (Boiss) O. Ktze	Non palatable	Mostly palatable	Non palatable
	Grasses			
7.	*Pennisetum orientale* L.	Highly palatable	Highly palatable	Highly palatable
8.	*Stipa pennata* L.	Highly palatable	Highly palatable	Highly palatable
9.	*Tetrapogon villosus* Desf.	Highly palatable	Highly palatable	Highly palatable
10.	*Cymbopogon jwarancusa* (Jones) Schult.	Least palatable	Least palatable	Least palatable

Table 2. Mineral constituents of some grasses and shrubs of Harboi hills (at three penological stages).

S. No.	Species	Phenological stages	K (ppm)	P (ppm)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Zn (ppm)
Grasses								
1	*Stipa pennata*							
		Pre-Rep. Stage	1.05	0.16	9.4	72.1	74	27.78
		Reproductive Stage	1.26	0.1	8.6	22.9	793	6.75
		Post Rep. Stage	1.31	0.1	4.4	59	160	8.6
		Mean	1.21	0.12	7.47	51.33	342.33	14.38
2	*Pennisetum orientale*							
		Pre-Rep. Stage	2.27	0.22	9.96	43.4	327	18.7
		Reproductive Stage	2.32	0.24	16.9	26.8	85.3	15.9
		Post Rep. Stage	15.6	0.16	7.38	116.6	1020	40.16
		Mean	6.73	0.21	11.41	62.27	477.43	24.92
3	*Tetrapogon villosus*							
		Pre-Rep. Stage	1.46	0.131	5.35	132.5	111	18.29
		Reproductive Stage	2.1	0.15	7.2	59	164	17.3
		Post Rep. Stage	1.3	0.13	8.6	28.8	1411	11.4
		Mean	1.62	0.14	7.05	73.43	562.00	15.66
4	*Cymbopogon jwarancusa*							
		Pre-Rep. Stage	0.95	0.1	3.33	97.5	102	16.61
		Reproductive Stage	1.28	0.16	5.1	90.5	661	7.72
		Post Rep. Stage	0.92	0.01	5.8	53.2	668	13.5
		Mean	1.05	0.09	4.74	80.40	477.00	12.61
Shrubs								
1	*Artemisia maritima*							
		Pre-Rep. Stage	0.001	0.16	5.8	11.7	426	30.12
		Reproductive Stage	2.22	0.24	12.7	17.5	138	46.6
		Post Rep. Stage	1.02	0.21	18.3	31.3	336	43.4
		Mean	1.08	0.20	12.27	20.17	300.00	40.04
2	*Perovskia abrotanoides*							
		Pre-Rep. Stage	1.14	0.15	15.5	35	145	19.6
		Reproductive Stage	2.13	0.28	11.4	9.7	976	37.4
		Post Rep. Stage Stage	1.02	0.13	8.6	35	694	34.7
		Mean	1.43	0.19	11.83	26.57	605.00	30.57
3	*Perovskia atriplicifolia*							
		Pre-Rep. Stage	2.03	0.26	12.7	25	391	65.8
		Reproductive Stage	1.83	0.13	11.4	19.5	960	39.3
		Post Rep. Stage	1.14	0.15	11.4	21.5	870	59.9
		Mean	1.67	0.18	11.83	22.00	740.33	55.00
4	*Convolvulus leiocalycinus*							
		Pre-Rep. Stage	1.05	0.084	5.35	84.8	1518	13.26
		Reproductive Stage	1.86	0.11	11.4	33.92	589	16.05
		Post Rep. Stage	1.38	0.21	7.2	49	562	3.1
		Mean	1.43	0.13	7.98	55.91	889.67	10.80
5	*Sophora griffithii*							
		Pre-Rep. Stage	0.75	0.15	1.31	33.92	167	9.36
		Reproductive Stage	0.85	0.33	10.3	32.9	194	9.91
		Post Rep. Stage	0.63	0.11	9.96	58.2	1006	8.7
		Mean	0.74	0.20	7.19	41.67	455.67	9.32
6	*Hertia intermedia*							
		Pre-Rep. Stage	1.81	0.22	11.4	28.7	246	37.5
		Reproductive Stage	3.43	0.13	16.9	58.2	543	26.1
		Post Rep. Stage	2.53	0.15	14.1	61.1	57	17.3
		Mean	2.59	0.17	14.13	49.33	282.00	26.97

Potassium: No significant differences in potassium contents were observed between grasses and shrubs and among the various phenological stages and among different plants (Tables 2&3). Among grasses (Table 2), the mean value ranged in between 1.05 - 6.73

while among shrubs (Table 2) the mean value varied in between 0.74 (*Sophora*) to 2.59 (*Hertia*). However, *Pennisetum orientale* at post reproductive stage had significantly high value (15.6). At least 0.5 ppm potassium is required by livestock (Anon., 1981, 1985) in feed for various physiological functions. The present study showed that potassium contents were quite high in all the tested plants at all the phenological stages, which generally might fulfil the requirement of grazing animals. In *Artemisia maritima* the potassium contents were low at pre-reproductive stage. Since it is most preferred palatable species that is available during early spring, therefore, there is possibility that livestock in Harboi range might face some potassium deficiency. However, other plants might compensate this deficiency. Azim *et al*., (1989) reported high potassium contents in forage plants in late season (August to October) and a similar trend was also observed in few species in the present case. However, other species did not follow this trend as there was an insignificant decline in potassium contents at post-reproductive stage. This agrees with Holechek *et al*., (1998) and Akhtar *et al*., (2007) who reported that herbaceous plants and grasses are nutritionally rich at early growing stage. Rehman & Mackintosh (1996) reported that livestock preferred high level (1.16%) of potassium in fodder species and the present investigation shows that, almost all plants had required level of potassium.

Phosphorous: Phosphorous is essential for strengthening the skeleton, teeth, improving blood plasma, assimilation of carbohydrates, fats protein synthesis and necessary for enzyme activation. Its deficiency causes poor growth and development of animals. Phosphorous is the most limiting mineral to productivity of grazing animals throughout the world because of low availability to range plants and loss through soil erosion (Vallentine, 1990; Holechek *et al.,* 1998; Akhtar *et al.,* 2007). No significant differences between grasses and shrubs and between the phenologcial stages and among the different plants, except at post reproductive stage (at $p< 0.01$), were observed (Table 3). The average phosphorous contents among grasses (Table 2) ranged in between 0.09 (*Cymbopogon*) to 0.21 (*Pennisetum*) and among shrubs (Table 2) it ranged from 0.13 (*Convolvulus*) to 0.2 (*Artemisia*, *Sophora*). Sheep and goats require a minimum of 0.16 to 00.37% phosphorous (Anon., 1981, 1985). The present study shows that phosphorous content of analyzed plants were generally lower than the suggested level during all the phenological stages (Anon., 1981, 1985). This agrees with the findings of Akhtar *el al*., (2007) who observed P deficiency in forage plants. It has been suggested that goats need 0.23% phosphorous during March to April and 0.21% in October, while sheep require 0.2% to 0.06% during spring and 0.23% in winter (Anon., 1981, 1985). Table 2 shows that the phosphorous contents of some analyzed shrubs might sufficiently meet the phosphorous requirement of grazing animals i.e., *Artemisia* at reproductive and post-reproductive stages, *Sophora* and *Perovskia abrotanoides* at reproductive stage and *Perovskia atriplicifolia* at pre-reproductive stage, and *Convolvulus leiocalycinus* at post reproductive stage had sufficient amount of phosphorous. All these species had low phosphorous contents at other phenological stages of growth. It was observed that phosphorous contents of plants generally declined with maturity of plants. This suggested that livestock grazing in the Harboi range might not face phosphorous deficiency during spring; but there might be phosphorous deficiency for the remaining grazing period. The phosphorous contents differed at various phenological growth stages and at similar growth stage among the species, which gives an advantage to grazing animals as phosphorous would be available in some of the plants throughout the grazing period. Our findings agree with those of Wahid (1990), who reported decline in the phosphorous contents with maturity of plants at Zarchi and Tomagh rangelands. Similarly, Azim *et al*., (1989) also observed decrease in phosphorous contents with increasing maturity of plants. This is correlated with the advancing season which moves towards dormant cold period after September.

Table 3. Statistical comparison of mineral constituents of grasses and shrubs at three phenological stages.

	Pre-reproductive		Reproductive		Post reproductive	
	Grass	Shrubs	Grass	Shrubs	Grass	Shrubs
Potassium						
	1.05	0.001	1.26	2.22	1.31	1.02
	2.27	1.14	2.32	2.13	15.6	1.02
	1.46	2.03	2.1	1.83	1.3	1.14
	0.95	1.05	1.28	1.86	0.92	1.38
		0.75		0.85		0.63
		1.81		3.43		2.53
Sum	**1.4325**	**1.13017**	**1.74**	**2.05333**	**4.7825**	**1.28667**
Variance	**0.36043**	**0.53959**	**0.30267**	**0.69283**	**52.0411**	**0.42991**
t-Test	**0.51482**	**0.49771**	**0.52986**	**0.49399**	**0.25808**	**0.40437**
	NS		**NS**		**NS**	
Phosphorous						
	0.16	0.16	0.1	0.24	0.1	0.21
	0.22	0.15	0.24	0.28	0.16	0.13
	0.131	0.26	0.15	0.13	0.13	0.15
	0.1	0.084	0.16	0.11	0.01	0.21
		0.15		0.33		0.11
		0.22		0.13		0.15
Sum	**0.15275**	**0.17067**	**0.1625**	**0.20333**	**0.1**	**0.16**
Variance	**0.00261**	**0.00378**	**0.00336**	**0.00855**	**0.0042**	**0.00172**
t-Test	**0.64391**	**0.63132**	**0.45862**	**0.41577**	**0.10861**	**0.16603**
	NS		**NS**		**S (0.1%)**	
Manganese						
	72.1	11.7	22.9	17.5	59	31.3
	43.4	35	26.8	9.7	116.6	35
	132.5	25	59	19.5	28.8	21.5
	97.5	84.8	90.5	33.92	53.2	49
		33.92		32.9		58.2
		28.7		58.2		61.1
Sum	**86.375**	**36.52**	**49.8**	**28.62**	**64.4**	**42.6833**
Variance	**1433.97**	**629.985**	**997.913**	**297.236**	**1382.27**	**251.438**
t-Test	**0.03522**	**0.07094**	**0.20299**	**0.28472**	**0.23162**	**0.33582**
	S		**NS**		**NS**	
Copper						
	9.4	5.8	8.6	12.7	4.4	18.3
	9.96	15.5	16.9	11.4	7.38	8.6
	5.35	12.7	7.2	11.4	8.6	11.4
	3.33	5.35	5.1	11.4	5.8	7.2
		1.31		10.3		9.96
		11.4		16.9		14.1
Sum	**7.01**	**8.67667**	**9.45**	**12.35**	**6.545**	**11.5933**
Variance	**10.2375**	**28.7543**	**26.7367**	**5.547**	**3.35877**	**16.4459**
t-Test	**0.59546**	**0.55589**	**0.25611**	**0.35466**	**0.05028**	**0.03059**
	NS		**NS**		**S**	

Table 3. (Cont'd.).

	Pre-reproductive		Reproductive		Post reproductive	
	Grass	**Shrubs**	**Grass**	**Shrubs**	**Grass**	**Shrubs**
Iron						
	74	426	793	138	160	336
	327	145	85.3	976	1020	694
	111	391	164	960	1411	870
	102	1518	661	589	668	562
		167		194		1006
		246		543		57
Sum	**153.5**	**482.167**	**425.825**	**566.667**	**814.75**	**587.5**
Variance	**13627**	**270641**	**124878**	**129192**	**282625**	**122325**
t-Test	**0.25731**	**0.18854**	**0.55823**	**0.56007**	**0.43369**	**0.48703**
	NS		**NS**		**S**	
Zinc						
	27.78	30.12	6.75	46.6	8.6	43.4
	18.7	19.6	15.9	37.4	40.16	34.7
	18.29	65.8	17.3	39.3	11.4	59.9
	16.61	13.26	7.72	16.05	13.5	3.1
		9.36		9.91		8.7
		37.5		26.1		17.3
Sum	**20.345**	**29.2733**	**11.9175**	**29.2267**	**18.415**	**27.85**
Variance	**25.3862**	**429.827**	**29.7179**	**205.328**	**214.182**	**481.303**
t-Test	**0.43097**	**0.35198**	**0.05284**	**0.03202**	**0.47547**	**0.4383**
	NS		**S**		**NS**	

S – Significant, NS - Non-significant

Copper: The shrubs generally had higher copper contents than the grasses (Tables 2&3). Among grasses (Table 2), it ranged from 4.74 (*Stipa*) to 11.41 ppm (*Pennisetum*), while it varied from 7.19 (*Sophora*) to 14.13 ppm (*Hertia*) among shrubs (Table 2). The copper contents were high at pre reproductive and reproductive stages, respectively in *Stipa* and *Pennisetum* and at post reproductive stage in *Tetrapogon* and *Cymbopogon* (Table 2). Copper contents were significantly higher at reproductive and post reproductive stages in shrubs, except *P. abrotanoides* (Table 2). The highest copper concentration was recorded for *Perovskia abrotanoides* and *Perovskia atriplicifolia* at pre reproductive stage, for *Convolvulus*, *Sophora* and *Hertia* at reproductive stage and for *Artemisia* at post reproductive stage (Table 2). Copper deficiency affects dietary intake of elements and causes anaemia. Livestock need 4.5 to 5 ppm copper but 8 to 25 ppm copper is toxic level (Anon., 1981, 1985). It was observed that copper contents were generally within the toxic limits in tested plants at most of growth stages, except *Stipa*, *Pennisetum* and *Convolvulus* at post-reproductive stage. *Artemisia* and *Convolvulus* at pre-reproductive and *Cymbopogon* at all three stages had toxic levels of copper. Copper contents of analysed species were higher than creeping blue stem (Kalmbacher & Martin, 1981). On the contrary, they were low compared to other forage as reported by Reuter *et al*., (1986). It was observed that Cu was generally high at post reproductive stages which is the on set of winter season, while Khan *et al*., (2006) reported lower values for Cu during winter than summer in forge plants. Akhtar *et al*., (2007) reported deficiency of Cu in forage plants analysed by them.

Manganese: Manganese deficiency causes impaired growth, skeletal abnormalities and infant abnormalities. Grasses on the average had significantly ($p = 0.05$) high manganese content than shrubs (Tables 2&3) at almost all phenological stages. Among the grasses (Table 2), it ranged from 51.33 (*Stipa*) to 80.4 ppm (*Cymbopogon*). In shrubs (Table 2) it varied from 20.17 (*Artemisia*) to 55.9 ppm (*Convolvulus*). Generally, Mn contents reduced at flowering stage (reproductive) in all the plants except in *Cymbopogon* and *Tetrapogon*, where post reproductive stage exhibited lowest value (Table 2). There existed non-significant differences in Mn contents among different plants and growth stages (Table 3). Khan *et al*., (2006) reported low Mn in plants during winter than in summer. We found almost similar trend for most of the analysed plants. The Mn contents in analysed species were well above 18 to 36 ppm, a range recommended by the Anon., (1981, 1985). Manganese contents were less than 18 ppm in *Artemisia* at pre-reproductive and in *Perovskia abrotanoides* at reproductive stage. The findings agree with those of Kalmbacher & Martin (1981) and Reuter *et al.* (1986), who reported similar range for Mn in other forage plants.

Iron: Iron is an essential component of haemoglobin, myoglobin, cytochrome and enzyme system involved in the transport of O_2 to cells. The differences were significant ($p = 0.05$) in Fe contents between various phenological stages of shrubs and grasses but non-significant between grasses and shrubs (Table 3). Among grasses (Table 2), the highest average Fe contents was observed in *Tetrapogon* (562 pp), followed by *Pennisetum* and *Cymbopogon* (477 ppm) and *Stipa* (342 ppm). The highest Fe contents were recorded in *Tetrapogon* (1411 ppm) and *Pennisetum* (1020 ppm) at post reproductive stage. Generally Fe contents progressively decreased with maturity of grasses. Among shrubs (Table 2), *Convolvulus* exhibited highest value (1518 ppm) at pre reproductive stage followed by *Sophora* (1006 ppm) at post reproductive stage. The present study showed that the analyzed plants had high Fe contents at all phenological stages. The dietary requirement of goats and sheep lies within 30 to 50 ppm (Anon., 1981, 1985). Iron contents in the recorded species were very high as compared to creeping blue stem (27.5 to 69.4 ppm.) (Kalmbacher & Matin, 1981). However, Reuter *et al.*, (1986) reported as high as 524 mg/kg Fe contents in mixed herbage feeds that are similar to our findings. Our findings also agree with those of Akhtar *et al*., (2007) who reported high Fe in forages for buffalo.

Zinc: Zinc is an activator of more than 30 enzymes in nucleic acid, protein synthesis and carbohydrates metabolism. Its deficiency interferes with reproductive capacity of animals. There were in-significant differences in Zn contents between grasses and shrubs. Among the grasses the differences were non-significant at pre and post reproductive stages but were significant at reproductive stage (Tables 2&3). Among the grasses, Fe contents varied from 12.61 ppm (*Cymbopogon*) to 24.92 ppm (*Pennisetum*). Except *Pennisetum*, Zn contents in other grasses reduced at reproductive and post reproductive stages. In shrubs (Table 2), Fe concentration ranged from 9.32 (*Sophora*) to 55.0 ppm (*Perovskia atriplicifolia*). Fe contents were high in *Perovskia atriplicifolia* and *Hertia* at pre reproductive stage and in *Artemisia*, *P. abrotanoides* and *Convolvulus* at reproductive stages (Table 2). Generally shrubs had higher Zn contents than grasses with insignificant seasonal variation (Tables 2&3). It has been suggested an intake of 35 to 50 ppm Zn, while an amount of 900 to 1000 ppm is toxic for livestock (Anon., 1981, 1985). In our case grasses were below the required intake level at all phenological stages while shrubs, with few exceptions, had the required level of zinc. Zinc contents of the investigated grasses of Harboi range were lower than other forage species (Kalmbacher & Martin, 1981; Reuter *et al.*, 1986). The nature of minerals and its balanced concentration varies with plant species, stage of growth and availability of minerals in the soil (Minson, 1982) and this agree with our findings.

Harapiak *et al*., (2004) suggested that nutrient and mineral deficient vegetation needs fertilization with commercial fertilizers to enhance fertility of soil and vegetation that will ensure supply on minerals to forage plants. The present findings suggest that besides enhancing the fertility of rangeland soil and vegetation, the grazing animals also need some additional source of minerals especially when the forage quantity and quality of forage is reduced below the required demand of livestock. It will not only improve reproductive capacity, body weight, birth weight of livestock and other valuable wildlife but also improve digestibility and absorption of other minerals and various nutrients (Yadave *et al.*, 2004; Chaturvedi *et al.*, 2006).

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