



## Evaluation of Macro Mineral Contents of Forages: Influence of Pasture and Seasonal Variation

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**ABSTRACT** : Concentrations of major elements in forages were determined in relation to ruminant requirements at a livestock experimental station in Leiah district, Punjab-Pakistan using mapping techniques. The study investigated the influence of sampling periods and pasture types on the concentrations of calcium, magnesium, potassium, and sodium in forages. The implications of these forages for nutrition of ruminants were assessed for the livestock population at that particular experimental station, which are supported by the farm pastures. Within the farm, variations in the element status of the forages were related to soil pasture types. A tentative assessment of the mineral status of available forages at this farm for different pastures using guidelines developed for domestic animals indicated deficiencies of only Na, but forages contained adequate Ca, Mg, and K levels required for grazing ruminants. The concentrations of Na in the forage reserves indicated that the potential supply of this element to plants was limited from the soil to plants and from plants to the animals grazing them. Soil minerals were not measured in this study. The potential use of fertilizers, as pasture amendment as well as supplementation of ruminants, with a specifically tailored mineral mixture is important to livestock producers and environmentalists as well, because their use may improve forage nutritive value and in turn meet requirements of animals. (**Key Words** : Forage, Macro-minerals, Arid Regions, Ruminants, Pastures)

### INTRODUCTION

The performance and health of grazing livestock is dependent on the adequacy and availability of essential mineral elements from pastures. Of the nutritional entities provided by the pasture, forage, minerals are the most variable. Pastures often fail to supply all needed mineral elements in adequate quantity to grazing ruminants (McDowell, 1996; Underwood and Suttle, 1999). Under pasture systems, animals depend on forages to satisfy all of their nutritional requirements. Unfortunately, forages often do not provide all of the needed minerals, which animals require throughout the year. Many incidences of mineral inadequacies in forages and soils have been reported, which are principal causes of reproductive failure and low production rates (McDowell, 1985, 1997; Vargas and McDowell, 1997). Mineral deficiencies likely to affect production of grazing livestock on pastures in most of the world regions include those of the major elements Ca, P, Mg, Na, S, and the trace elements Co, Cu, I, Mn, Se, and Zn

(Little, 1982; Judson et al., 1987; Judson and McFarlane, 1998).

Livestock improvement demands the efficient use of available feed resources. Factors like climate, agronomic practices, feed processing technologies and genetic variations ultimately affect the nutritive value of feed for livestock. Feeding resources and feeding systems of farm animals vary from one place to another. The farmer's land holdings, socio-economic status and marketing of livestock and their products govern feeding practices. This study deals with the extent of the minerals in forages available and their potential in meeting the animal needs and maintaining their health status in the next decades in the Punjab province.

The nutrition of grazing animals is a complicated interaction of soils, plants, and animals. Seasonal variability can markedly affect the dietary intake of minerals as a result of changes in composition, stage of growth, availability of pasture, and to changes in the moisture content of the soil (Smith and Loneragon, 1997). Pasture and soil tests are perceived to be the initial tools for diagnosis of animal deficiencies. If pasture samples are taken in association with the animal samples, an explanation of the predisposing

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Received June 21, 2006. Accepted February 7, 2007

pasture conditions may be assessed and subsequent routine plant analyses may be able to predict the variable incidence of mineral problems. The advantage of this is the ease and comparative lower cost of plant tissue analysis when compared with the collection and testing of blood or tissue samples from animals.

The livestock sector is an integral part of agriculture in Pakistan. Livestock accounts for 37% of the agricultural GDP and about 9% of the total GDP. This is derived from a livestock population of about 25.5 million buffaloes, 23.8 million cattle, 24.7 million sheep, 54.7 million goats, and 5.4 million other animals (Economic Survey 2003-04). Based on the previous census in 1998, 13.1 million buffaloes, 9.38 million cattle, 6.14 million sheep, 15.3 million goats, and 2.37 million other animals were found in the Punjab province.

In Pakistan the area under fodder production is about 3.35 million hectares out of a total cropped area of 21.85 million ha, in the country, producing more than 60 million tones of fodder (Economic Survey, 2003-04). The area under fodder in Punjab is 2.03 million ha, with a production of 45 million tones of fodder crops with an average yield of 22 tones/ha, which is not sufficient, even to meet the maintenance requirements of the livestock.

There is scanty information on the mineral nutritive potential of forages in different arid and semiarid regions of the world including those of the province of Punjab, Pakistan. The forages from these drought-hit areas are important components of feed for livestock during the critical dry seasons. Furthermore, very little has been done to establish levels of minerals of these feed resources. Knowledge on mineral composition of forages would form base-line data on mineral status of available feed resources for enhanced nutrition of grazing ruminants in semi-arid and arid areas of Southwestern region of Punjab, Pakistan. The purpose of this investigation is to use plant analysis as indicators of likely mineral deficiencies or excesses of grazing livestock during different seasons.

## MATERIALS AND METHODS

Pakistan is a predominantly agricultural country with a semiarid continental subtropical climate characterized by two distinct seasons, winter and summer. The soils of the whole country and particularly province of Punjab are alkaline calcareous and major nutrient deficiencies are with N, P, Zn, K, B, and Fe (Memon et al., 1992; NFDC, 1993). It is located between 23° and 36° N latitude and 60° and 75° E longitude and comprises four provinces: The Punjab, Sindh The Northwest Frontier Province (NWFP), and Balochistan. Its total geographical area is 80 Mha, of which 27.5 percent (21.89 Mha) is cropped.

This study was conducted at the Livestock Experimental Station Rakh Khair Walla, Distt. Leiah in southwestern Punjab, owned by the Government of Punjab, Pakistan. This Livestock Experimental Station has five different farms. This study was carried out on eight different pastures having goat and sheep populations. These pastures are situated nearly 0.5 km away from one another. These farm pastures were 140 hectares and established 40 years ago. The main forage species in all pastures in which the experimental animals grazed were available from October through April include berseem (*Trifolium alexandrinum*), barley (*Hordeum vulgare*), lucerne or alfalfa (*Medicago sativa*), mustard/rape (*Brassica spp.*), oats (*Avena sativa*), raya (*Brassica juncea*) and sugar cane (*Saccharum officinarum*) as a whole plant or tops during Rabi fodders (winter fodders). Kharif fodders (summer fodders) are grown from May through September. These include cowpea (*Vigna unguiculata*), dwarf elephant grass, guar (*Cyamopsis tetragonoloba*), Jantar or Dhaincha (*Sesbania aculeata*), maize (*Zea mays*), millet (*Pennisetum typhoides*), moth (*Phaseolus aconitifolius*), mung (*Vigna radiata*), Napier grass, sorghum (*Sorghum bicolor*), Sudex (*Sadabahar*), sugar beet tops (*Beta vulgaris*) and Swank (*Pennisetum glaucum*) and additional supplementations with free choice mineral mixture. Average temperature during the experimental year was between 38±5°C during summer and 15±7°C during winter; relative humidity 48±5% during summer and 80±8% during winter. The farm flock was composed of approximately 2000 mixed breed dairy goats and sheep, which were pastured all year long.

Forage samples were collected six times once every month beginning January to June during the year. Three composite forage samples from each of the eight pastures assigned to the experiment were collected each sampling period. Each composite sample forage was derived from three sub-samples, collected from three different sites in these pastures. The sub-samples of forages were collected from an area approximately 70 cm in diameter, and cut to a length of 3-6 cm to simulate grazing height. The principal forage species from all pastures were various grasses and to a lesser extent, all pastures were associated with some varieties of forages. A total of 144 forage samples were collected in all the collecting periods, 18 samples per pasture.

The forage samples were cut using a stainless steel knife and placed in clean cloth bags on location. They were dried in an oven at 60°C for 48 h and subsequently ground, using a Wiley mill, with a 1 mm stainless steel sieve. Ground samples were stored in plastic whirl-pack sample bags until analysis. Forage samples were prepared and digested according to procedures of Fick et al. (1979), and analyzed for Ca, Mg, K, and Na by atomic absorption

**Table 1.** Analysis of variance of data for macro-mineral concentrations in forages as related to pastures and sampling months

Source of variation	Degree of freedom	Means squares			
		Calcium	Magnesium	Potassium	Sodium
Month (M)	5	0.0062***	0.0036***	1.0092***	0.00033***
Pasture (P)	7	0.053***	0.0069***	0.211***	0.00021***
MS×P	35	0.054***	0.0014*	0.047***	0.000036***
Error	96	0.0013	7.72	0.0086	0.0000063

\* \*\* Significant at 0.05 and 0.001 levels, respectively.

**Table 2.** Effect of pastures on the macro-mineral concentrations (% DM) of forages

Minerals	Pasture-A	Pasture-B	Pasture-C	Pasture-D	Pasture-E	Pasture-F	Pasture-G	Pasture-H
Ca	0.315 <sup>1</sup>	0.345 <sup>a</sup>	0.381 <sup>cd</sup>	0.385 <sup>c</sup>	0.359 <sup>de</sup>	0.443 <sup>b</sup>	0.384 <sup>c</sup>	0.492 <sup>a</sup>
Mg	0.231 <sup>2</sup>	0.256 <sup>bc</sup>	0.266 <sup>b</sup>	0.239 <sup>cd2</sup>	0.236 <sup>de</sup>	0.291 <sup>a</sup>	0.259 <sup>bc</sup>	0.253 <sup>bcd</sup>
K	1.38 <sup>c</sup>	1.18 <sup>e</sup>	1.46 <sup>b</sup>	1.40 <sup>bc</sup>	1.54 <sup>d</sup>	1.36 <sup>d</sup>	1.46 <sup>b</sup>	1.45 <sup>b</sup>
Na	0.016 <sup>cd</sup>	0.022 <sup>ab</sup>	0.015 <sup>d</sup>	0.021 <sup>b</sup>	0.013 <sup>e</sup>	0.023 <sup>a</sup>	0.016 <sup>cd</sup>	0.017 <sup>c</sup>

<sup>a-f</sup> Means with the same letters do not differ significantly at  $p \leq 0.05$ .

spectrophotometry on a Perkin-Elmer AAS-5000 (Perkin-Elmer, Corp, 1980).

### Statistical analysis

Analysis of variance (ANOVA) of the data was computed using a COSTAT computer package (CoHort Software, 2003, Monterey, California). The comparison of means was done by the same computer package, using Duncan's New Multiple Range Test (DMRT)(Duncan, 1955).

## RESULTS AND DISCUSSION

Data for the different forage species were pooled within each sampling month and pasture to assess the influence of pasture and sampling month which were found to be significant ( $p < 0.001$ ) in forage Ca concentration due to month, pasture and interaction between them (Tables 1 and 2). Mean forage Ca concentrations varied from 0.315 to 0.492% DM (pasture-A and H). Forage Ca concentration in pastures C and D was found to be equal statistically and B and E were also similar while in pasture G it was slightly higher than those in afore-mentioned pastures, but was lower than in forages harvested from pasture H. Mean Ca concentrations from all sampling sites during different sampling periods were above the critical value of 0.30% DM (National Research Council, 1984) for different classes of ruminants). Mean Ca concentration among months were also found to be different ( $p < 0.001$ ). It ranged from 0.366 to 0.406% in the sampling months of January and February, respectively (Table 3). Forage Ca requirements of grazing ruminants is a subject of considerable debate as the requirement is influenced by animal type and level of production, age and weight of ruminants. Reuter and Robinson (1997) suggested Ca requirement for maintenance, growing and lactating sheep to be 1,200-2,600 mg/kg. Thus, the forage Ca values found in this study was considered

adequate for the optimum performance of ruminants. Similar forage Ca values as found in this study were reported by Pastrana et al. (1991) in Colombia, Tiffany et al. (2000, 2001) in North Florida, Espinoza et al. (1991) in Central Florida and Cuesta et al. (1993) in North Florida. It is generally recommended that diets of livestock should have Ca:P ratio of about 1:1 to 2:1 (Underwood, 1981). Livestock will tolerate dietary Ca:P ratios of more than 10:1 without any serious effect provided the P intakes are adequate (Ternouth, 1990). Temperate forages generally contain more Ca than those grown in the tropics. However, hay from Ireland had a mean Ca concentration almost similar to that found in this study during winter from the forage, which was also similar to that reported by the Pennsylvania State Forage Test Service (Adams, 1975). The forage means level of Ca was found higher than that the requirements of grazing ruminants. High levels of Ca of these conserved forages would meet the theoretical Ca requirements of 0.30% DM Ca diet needed for all forms of production in ruminants (ARC, 1980). These forages had higher levels of Ca than dietary requirement of growing cattle, lactating dairy cows, growing lambs) and lactating ewes. However, efficiency of Ca utilization from these forages, and therefore its bioavailability in ruminants, would depend on presence of adequate level of P, active form of vitamin D, and calcitonin and parathyroid hormone (PTH). Calcitonin and PTH mobilize conversion of vitamin D to its active form.

The grazing land forages had significant variation ( $p < 0.001$ ) in the levels of Mg due to month, pasture and interaction between them and it ranged from 0.231 (pasture-A) to 0.291% DM in forages harvested from pasture-F, which had ( $p < 0.001$ ) highest levels of Mg (Tables 1 and 2). There was no difference in the content of Mg between forages harvested from pasture-B, C, G and H, while pastures D and F had forage Mg equal to that of pasture-H. In relation to sampling months, the Mg levels varied

**Table 3.** Effect of months on macro-mineral concentrations (% DM) of forages

Minerals	January	February	March	April	May	June
Ca	0.366 <sup>c</sup>	0.406 <sup>a</sup>	0.372 <sup>c</sup>	0.378 <sup>bc</sup>	0.394 <sup>ab</sup>	0.399 <sup>ab</sup>
Mg	0.263a <sup>b</sup>	0.268 <sup>a</sup>	0.246 <sup>bc</sup>	0.250 <sup>abc</sup>	0.265 <sup>ab</sup>	0.235 <sup>c</sup>
K	1.52 <sup>b</sup>	1.64 <sup>a</sup>	1.50 <sup>b</sup>	1.40 <sup>c</sup>	1.20 <sup>d</sup>	1.10 <sup>e</sup>
Na	0.022 <sup>a</sup>	0.016 <sup>c</sup>	0.019 <sup>b</sup>	0.021 <sup>a</sup>	0.017 <sup>c</sup>	0.012 <sup>d</sup>

<sup>a-e</sup> Means with the same letters do not differ significantly at  $p \leq 0.05$ .

significantly ( $p < 0.001$ ): it ranged from 0.235 to 0.268% DM in the months of June and February, respectively followed by the months of May, January, April, and March, respectively (Table 3). The high forage Mg level found in this study was above the requirement of ruminants suggested by National Research Council (1985), and no forage sample was below the critical level of 12-0.20% DM. Similar adequate values for forage Mg were reported by Salih et al. (1983) in Florida. The grazing land forages had lower levels of Mg than most tropical grasses (Minson, 1990). However, differences in the content of Mg in this study with those in the literature could be partly explained by differences between forage species, level of Mg in the soil, influences of locality and climate, growth stage, proportion of leaf and stem fractions collected for mineral analysis, and season when herbage sampling was done. The grazing land forages had slightly higher levels of Mg than the recommended requirement of 0.12-0.20% DM in the diet of ruminants (ARC, 1980, National Research Council, 1985). These forages would therefore meet the theoretical requirement of Mg for beef cattle (National Research Council, 1996) and for lactating cows (National Research Council, 2001). These forages had also higher levels of Mg than the recommended requirements for growing lambs and lactating ewes (INRA, 1989), and goats (Meschy, 2000; Khan et al., 2006). According to Dua and Care (1995) the dietary Mg availability to stock is markedly affected by other dietary components, especially K. High dietary levels of K and N will inhibit Mg absorption from the rumen. Ca and soluble carbohydrates may respectively increase and decrease dietary Mg requirements of livestock, whereas raised dietary P levels appears to lower the requirements for both Ca and Mg (Judson and McFarlane, 1998).

There was a significant difference ( $p < 0.001$ ) in the content of K among the grazing land forages for month, pasture and due to interaction of month and pasture. Potassium content ranged from 1.18 to 1.54% DM (pasture-B and pasture-E, respectively) (Tables 1 and 2). While K contents of those forages which were harvested from pastures C, D, G and H were found to be equal statistically and that of pastures A and D forage potassium contents were also similar. Based on sampling period the forage K level differed significantly ( $p < 0.001$ ) it varied from 1.10 to 1.64% DM in the months of June and February, respectively while in the months of January and March it was at par followed by April and May, respectively (Table

3). Plant age generally has a greater influence on forage K than soil K concentrations and it has been observed that young plants have higher K than that in mature plants (Tiffany et al., 2000, 2001).

Forage K concentrations during this study were within the range for the normal requirements of animals (0.8% DM) (ARC, 1980). It tended to be higher in some forage samples during this investigation. Similar K concentrations were also reported by Prabowo et al. (1990) in Indonesia, Ogebe et al. (1995) in Nigeria, and Tiffany et al. (2000, 2001) in North Florida.

Potassium in different growing forages commonly is quite high (McDowell and Valle, 2000). Thus, the grazing livestock consuming primarily a forage diet would receive adequate K. In certain regions of the world, it is possible that K deficiency could arise, in view of decreasing content of this mineral with increasing forage maturity (McDowell and Valle, 2000). High forage diets typically contain several times the amount of K present in high grain diets. K is not readily stored and must be supplied daily in the diet.

Content of Na ranged from 0.013 (Pasture-F) to 0.023% DM in forages harvested from Pasture-F. There was a significant variation due to month, pasture, and interaction between them ( $p < 0.001$ ) in the content of Na among grazing land forages (Tables 1 and 2) The forage Na in pastures, A, G and H was found to be similar statistically and in pastures B and E was in equal amounts statistically. However lower Na values of forages were observed during this investigation. Mean forage Na significantly differed among sampling periods ( $p < 0.001$ ) ranging from 0.012 to 0.022% DM in the months of June and January, respectively. It was similar in the months of February and May and in January and April, while in the month of March it was higher than those in February, May and June, but lower than those in the months of January and April (Table 3). These values were deficient because of being lower than the critical value of 0.06% DM (requirement of ruminants) according to National Research Council (1985). This widespread deficiency in forage Na is in agreement with some earlier findings (McDowell et al., 1993), that the most prevalent mineral deficiency for grazing animals in the world was Na. In addition, deficiency of this element has been reported in many developing countries, e.g. Nigeria (Ogebe et al., 1995), and Colombia (Pastrana et al., 1991; Kim et al., 2006).

The content of Na in the ration is important in

determining the adequacy of the minerals. To meet the need of highly productive animals, forage should contain more than 0.15% DM sodium (Netherlands Committee on Mineral Nutrition, 1973). Na deficiency is more likely to occur in animal grazing tropical pasture species and these plants generally accumulate less Na than temperate species (Morris, 1980). Natural forages low in Na have been reported in numerous tropical countries throughout the world (McDowell, 1985).

### CONCLUSION

Based on this investigation it is concluded that there was severe deficiency of Na in forages, while forages contained adequate concentrations of Ca, Mg, and K in all pastures for grazing ruminants. But these macro minerals were not much higher than the required range for ruminants grazing therein. Therefore, supplementation of Na in all pastures and in some locations other macro minerals would seem most important for optimum productivity of grazing ruminants during different times of the year.

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