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EVALUATION OF MINERAL COMPOSITION OF FORAGES FOR GRAZING RUMINANTS IN PAKISTAN

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Abstract

The current research on the assessment of mineral composition of forages for grazing ruminants was carried out at the Government Livestock Experimental Station in Central Punjab, Pakistan. The aim of the study was to determine and collect data on the mineral contents of forages or feedstuffs that are harvested and used in animal nutrition in the region. The pastures of the station were visited twice, in summer and winter for sampling so as to determine the effect of seasonal changes on the mineral contents of forages. Forage samples were analyzed to determine some macrominerals (Na, K, Ca and Mg) and microminerals (Mn, Fe, Zn and Cu) levels. These results showed that pasture grasses/ forages have sufficient levels of K, Ca, Mg, Mn, Fe and Zn to meet the requirements of ruminants being reared there but the occurrence of marginal to deficient supplies of Na and Cu appears very likely in this area of investigation. Food supplements containing Na and Cu are recommended for maximizing the potential of livestock production in this particular ranch of animals.

Introduction

Livestock usually derive most of their dietary nutrients from the feed they eat; however, significant quantities of minerals may be obtained from water and soil sources. Feed sources of minerals are generally divided into various base feedstuffs such as range or pasture plants, harvested forages, concentrates and mineral supplements (McDowell & Arthington, 2005). However, efforts to minimize the cost of mineral supplementation in livestock production require a thorough knowledge of the supply and availability of mineral nutrients in feed and forages (Dost *et al*., 1990).

An adequate intake of forages and minerals in base feedstuffs by grazing animals determines the level of mineral consumption. The level of minerals in plants depends on interactions amongst a number of factors including soil type, plant species, stage of maturity, dry matter yield, grazing management and climate (McDowell *et al.*, 1983; Khan *et al.,* 2005). Although information on total concentration of a mineral in a feedstuff is important, that on the bio-availability of the mineral is equally important that varies considerably among animal species and breeds within a species, as well as among different feedstuffs. The combination of these factors makes it extremely difficult for livestock producers to determine the actual mineral status of their herd, their need and degree of supplementation to achieve the optimal production (Dost *et al*., 1990; Dost, 1997, 2001).

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In Pakistan as well as in other Asian countries, malnutrition occurs in poorly managed livestock. Grazing animals in Pakistan depend mainly on poor quality feedstuffs in non-developed pastures in arid and semi-arid regions (Khan *et al.,* 2007). In a few of the animal production centres where improved management practices are undertaken, the main supplements for energy and protein are agro-industrial by-products such as cereal brans, molasses and oilseed cake. However, little attention is given to the mineral balance of such diets. Although the available energy and protein of a feed are of vital importance to any animal, optimal production is only possible if there is an adequate supply of minerals (McDowell, 1985; Khan *et al*., 2004). In Pakistan, ruminants are rarely subsisted with mineral supplements except occasionally common salt. Pastures are thus the main source of minerals and forages rarely satisfy all these requirements of livestock (Miles & McDowell, 1983). Hence, it is important to appraise the mineral-nutrient concentrations of new plants (McDowell, 1992; Khan *et al.,* 2006).

Various aspects of mineral nutrition of grazing ruminants that address seasonal/ maturity changes in nutritive quality of native range/pasture plants in south-western Punjab, Pakistan, have been studied (Khan, 2003; Khan *et al.,* 2005, 2006, 2007). These include the effect of forage intake on mineral bio-availability, water stress, soil fertility, type of a crop and grazing management on forage chemical composition.

Due to increased demand, improved forage crops such as multi-cut oats, *Trifolium, Medicago,* Sorghum-Sudan grass hybrids, *Sorghum,* maize and millet have been developed. These crops are now very popular in irrigated areas of Punjab such as Kasur, Sheikhupura, Gujranwala, Faisalabad, Sargodha, Jhang, Leiah and Renala Khurd, and of NWFP such as Nowshera, Charsada, Mardan and Peshawar and of Sind such as Hyderabad, Sukkur, Larkana, Halla and Nawabshah, for sale to peri-urban dairies. Therefore, this study was aimed to evaluate the mineral composition of different forages both in natural pasture and improved varieties in relation to mineral requirement of ruminants so as to device various strategies for mineral supplementation for livestock at this semi-arid region. This evaluation of forage nutritive status would be useful for Pakistan as well as other Asian countries with similar climate and ecological conditions.

Materials and Methods

Samples of forages, trees, and grasses were collected twice from the grazing and browsing lands from different pastures Livestock Experimental Station in Punjab, Pakistan from different sites in the pastures of livestock's Farm situated 450 km off Islamabad, the capital of Pakistan. All the samples were from the natural and improved pastures and obtained by pooling core samples from three sites within the pasture. The species collected were: *Cynodon dactylon, Cynodon plectostachum, Pennisetum purpureum, Andropogon gayanus, Acacia brevispica Prosopis cineraria, Lolium multiflorum, Sorghum sudanense, Pennisetum americanum, Vigna radiata, Panicum miliaceum, Vigna acontiofolia, Paspalum conjugatum, Drymaria cordata* and improved pasture hay of *Medicago* spp., were taken as described above from stacks of forages at these sites harvested in June and August during summer and January and February during winter.

The leaves from *Albizzia lebbek* trees grown at the farm for grazing livestock in the pasture of that specific site were harvested. Samples were taken by pooling the leaves from mature trees. Leaves from the trees in the pastures were further separated into young and old. Pods with seeds on trees from the pasture were first air-dried and then separated into pods and seeds. Samples of *Salvadora oleoides* were taken from a plain lower area at a Government Research Station in the pasture. The samples of *Prosopis* spp., commonly being consumed by the browsing ruminants at this ranch were also collected for mineral status evaluation study. Samples of forage remains were taken from the pastureland using the same procedures as for other forages. The residues were collected from the natural pasture and improved varieties of forages grown therein, and most of them were being used in feeding experiments.

Chemical and statistical analysis: The samples were dried and prepared according to the method (Anon., 1990). Samples were prepared for mineral analysis by the wet digestion method using concentrated sulphuric acid and hydrogen peroxide. The concentrations of K, Na, Ca, Mg, Fe, Mn, Zn and Cu were determined using an atomic absorption spectrophotometer Perkins-Elmer Model, 1984. The data so obtained were analyzed (Anon., 1987). Differences between means were ranked using Duncan's New Multiple Range Test (Duncan, 1955).

Results and Discussion

The analytical results for all forages, trees and grasses are presented in Figures 1-10.

Sodium: The Na requirement for ruminants is although debatable yet its adequate range from 1-4 g/kg has been recommended (Underwood, 1981; Little, 1987). Sodium concentrations in forages were below the levels recommended for optimal animal production. The present data show that with the exception of *Albizzia lebbek,* most of the forage samples examined were very poor sources of Na, so that routine supplementation is necessary. These values were deficient lower than the critical values as reported (Anon., 1985; Sial, 1991; Khan *et al.,* 2007). This widespread deficiency in forage Na is corroborated with some earlier findings (McDowell *et al.,* 1993), that the most prevalent mineral deficiencies for grazing animals in the world were those of Na. In addition, deficiency of this element has already been reported in many regions of the world (Pastrana *et al.,* 1991; Areghoere, 2002).

Potassium: In present investigation the level of K in all the forages was over 8 g/kg recommended for grazing animals (Underwood, 1981). However, it has been suggested that ruminants with high producing, may require K level above 10 g/kg, under stress particularly heat stress (McDowell, 1985; Khan *et al.,* 2005). 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.

Calcium: Forage Ca requirements of grazing ruminants are influenced by animal type and level of production, age and weight (McDowell, 1985). Reuter & Robinson (1997) suggested Ca requirement for maintenance of growing and lactating sheep to be 1.2-2.6 g/kg. Furthermore, forage Ca values as found in summer in the present study have similar to those were reported by Pastrana *et al.,* (1991a,b) 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.

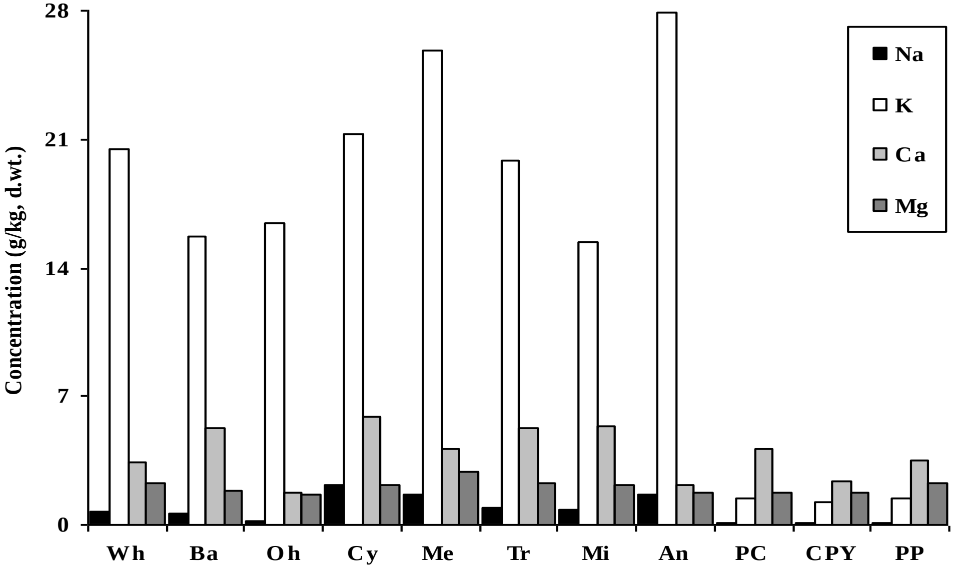

Fig. 1. Macromineral contents of some dried leaves of different forages [Wheat (Wh), Barley (Ba), Oats hay (Oh), *Cynodon* (Cy), *Medicago* (Me), *Trifolium* (Tr), Mixed (Mi), *Andropogon* (An), *Paspalum cojugatum* (PC), *Cynodon plectostachchyum* CPY), *Pennisetum purporeum* (PP)].

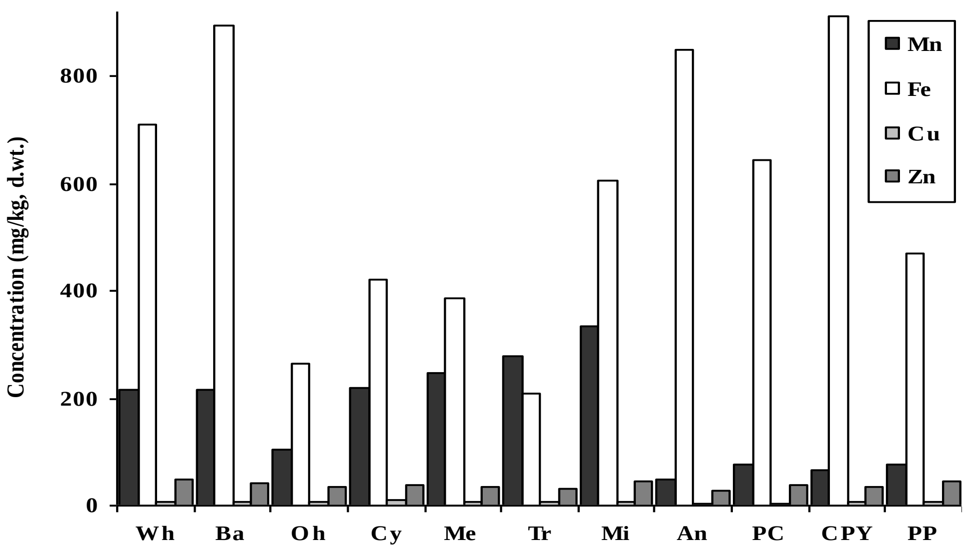

Fig. 2. Micromineral contents of some dried leaves of different forages [Wheat (Wh), Barley (Ba), Oats hay (Oh), *Cynodon* (Cy), *Medicago* (Me), *Trifolium* (Tr), Mixed (Mi), *Andropogon* (An), *Paspalum cojugatum* (PC), *Cynodon plectostachchyum* CPY), *Pennisetum purporeum* (PP)].

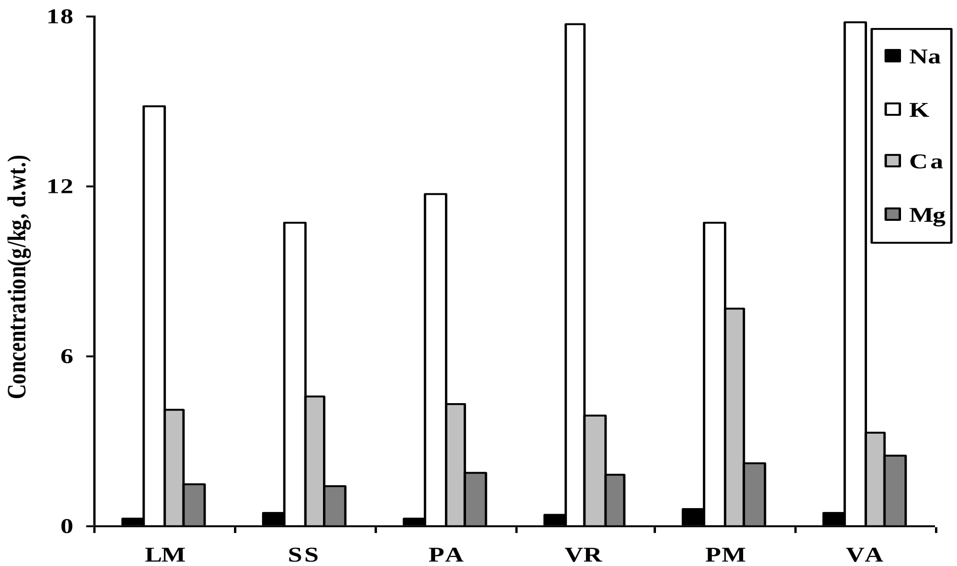

Fig. 3. Macromineral contenst of some dried leaves of different forages residues [*Lolium multiforum* (LM), *Sorghum sudanese* (SS), *Pennisetum americanum* (PA), *Vigna radiata* (VR), *Panicum miliaceum* (PM), *Vigna aconitofolia* (VA)].

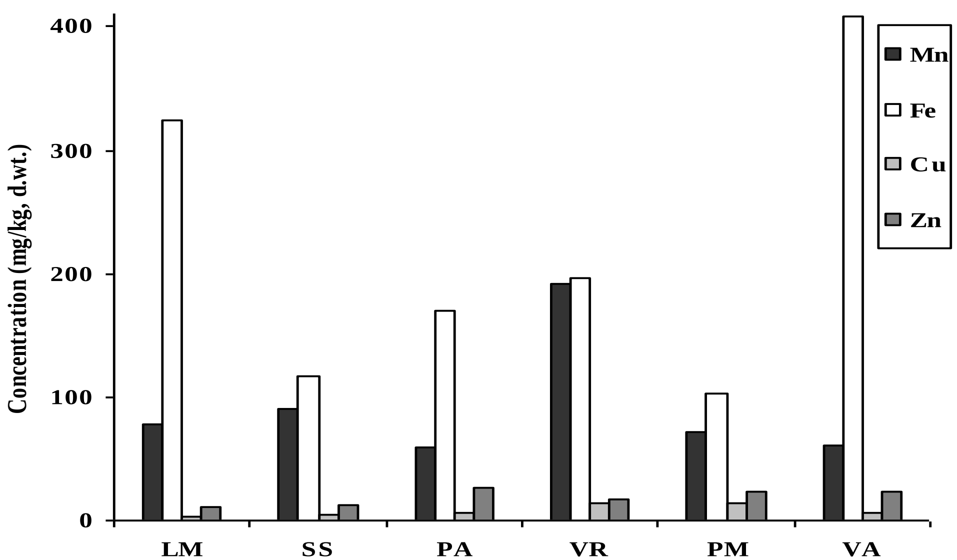

Fig. 4. Micro mineral contents of some dried leaves of different forages residues[*Lolium multiforum* (LM), *Sorghum sudanese* (SS), *Pennisetum americanum* (PA), *Vigna radiata* (VR), *Panicum miliaceum* (PM), *Vigna aconitofolia* (VA)].

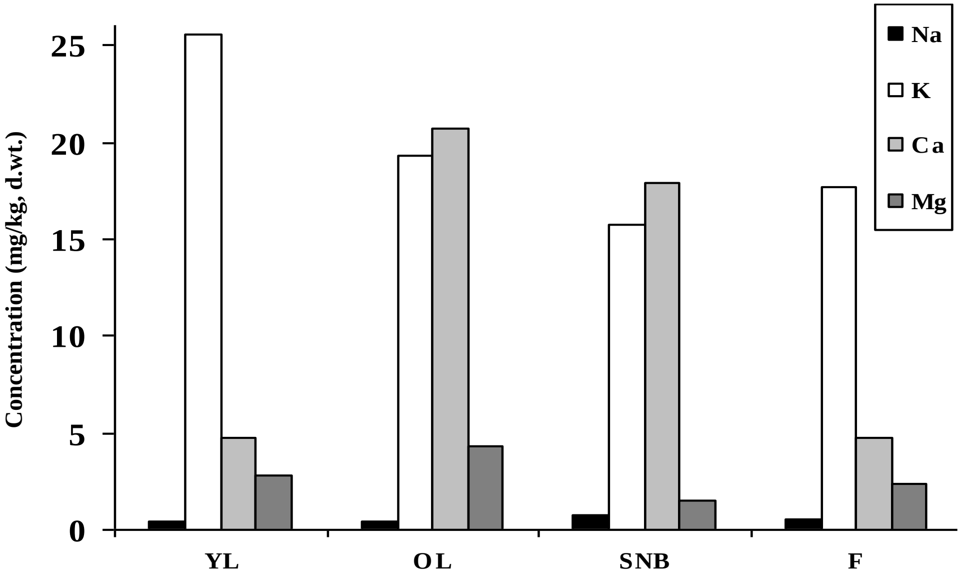

Fig. 5. Macromineral contents of *Salvodora oleioides*. [Young leaves (YL), Old leaves (OL), Small new branches (SB), Fruits (F)].

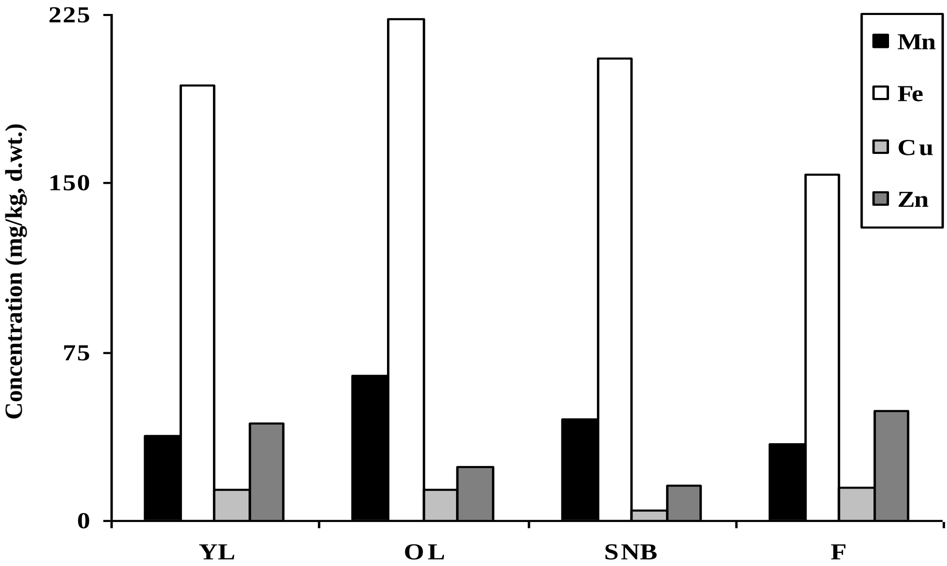

Fig. 6. Micro mineral contents of *Salvodora oleioides*. [Young leaves (YL), Old leaves (OL), Small new branches (SB), Fruits (F)].

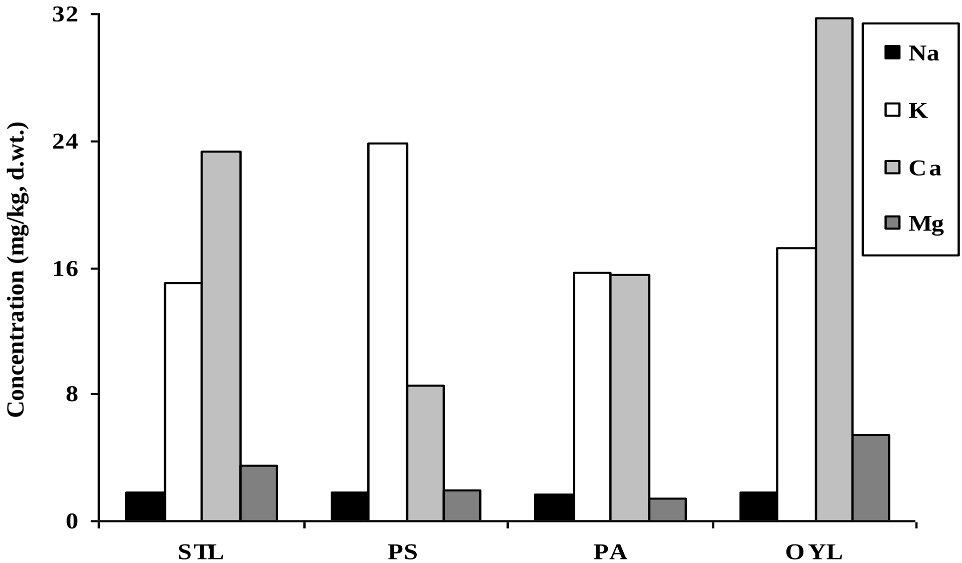

Fig. 7. Macromineral contents of *Albizzia lebbek* [Small twigs with leaves (STL), Pods with seeds (PS), Pods alone (PA), Old and young leaves (OYL) and Old and young leaves (OLY)].

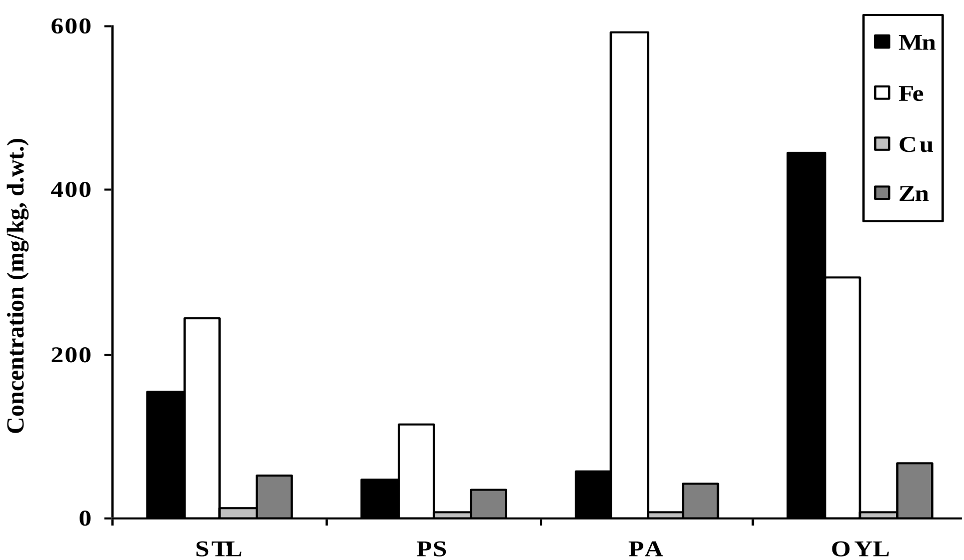

Fig. 8 Micromineral contents of *Albizzia lebbek* [Small twigs with leaves (STL), Pods with seeds (PS), Pods alone (PA), Old and young leaves (OYL).

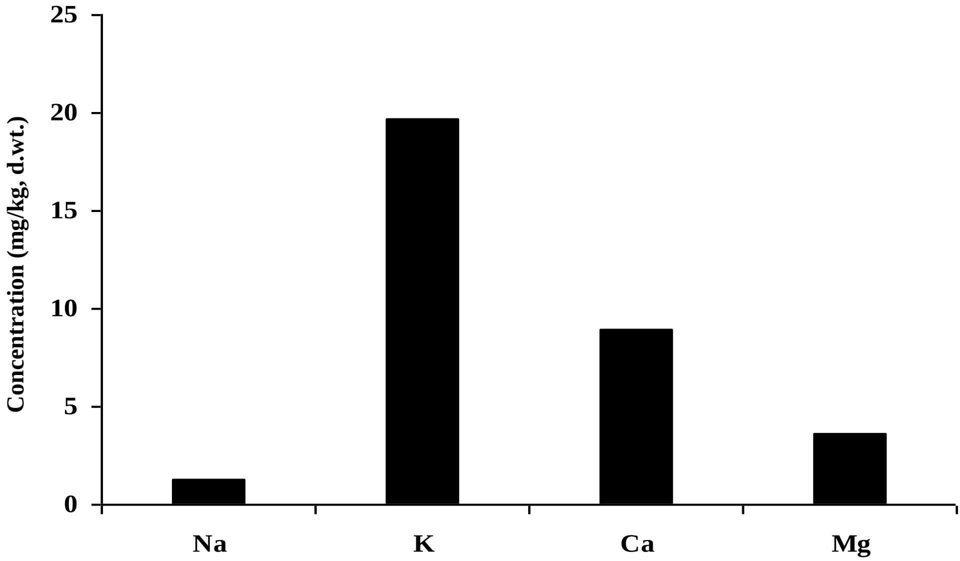

Fig. 9. Macromineral contents of *Prosopis cineraria.*

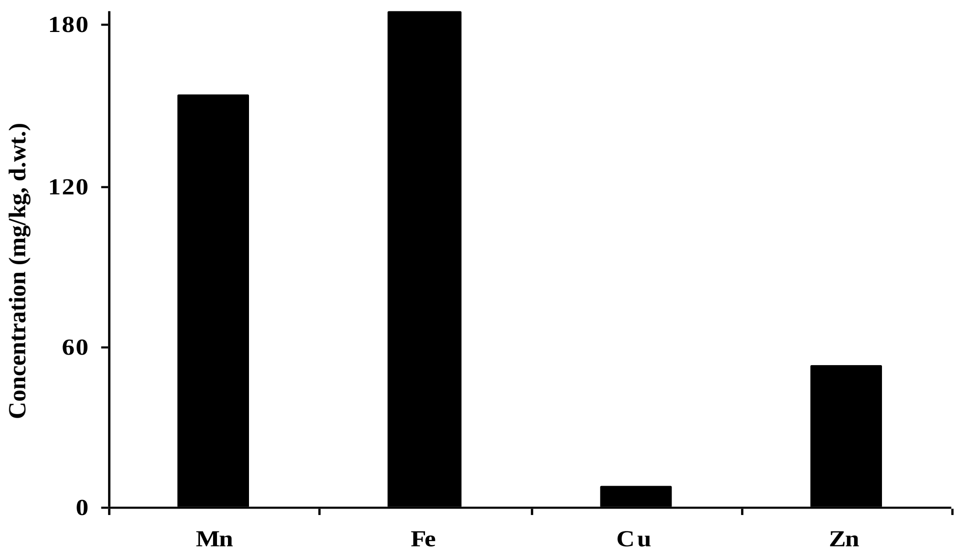

Fig. 10. Micromineral content of *Prosopis cineraria.*

Forage Ca concentrations in the range of 2-6 g/kg, with higher requirements for lactation have been variously recommended for cattle and sheep (Anon., 1980, 1985; Khan *et al.*, 2006). However, Sykes & Field (1972) suggest that levels of 2.5 g/kg are adequate in most circumstances. Variations in the levels of Ca between the present findings and those already reported in the literature could be partly explained due to mature forage species, species composition, and variations in soil characteristics due to location of the different grazing pastures at the ruminant ranch in this semi-arid region of Punjab, Pakistan. Overall, mean forage Ca concentrations were adequate and sufficiently higher than those normally required by the ruminants.

Magnesium: The grazing pasture forages had slightly higher levels of Mg than the recommended requirement (Anon., 1980; Islam *et al*., 2003). These forages would therefore meet the theoretical requirement of Mg for beef cattle (Anon., 1996, Khan *et al.*, 2007). These forages have also higher levels of Mg than the recommended requirements for growing lambs and lactating ewes and goats (Meschy, 2000). The native and unimproved pasture forages have lower levels of Mg than most species of forages and grasses, however, differences in the content of Mg in this study with those in the literature could partly be 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 forage sampling was done.

Manganese: Forage Mn levels were above 40 mg/kg, the critical level (Anon., 1996) and found to be sufficiently higher to meet the requirements of ruminants. Similar levels of forage Mn concentrations have already been reported in Nicaragua (Velasquez-Pereira *et al.*, 1997), Indonesia (Prabowo *et al.*, 1991) and in Guatemala (Tejada *et al.*, 1987; Khan *et al.*, 2007). On this ranch, mean forage Mn concentrations were although reasonably high, they were still below the maximum tolerable levels (Anon., 1985).

The low soil Co level found in this ranch by Khan (2006) is also a possible explanation of high level of Mn in forage as these elements antagonize in the soil (McKenzie, 1975; Yaun *et al.*, 2006; Khan *et al.*, 2007).

Iron: The forage Fe values were above 50 mg/kg, an adequate level for grazing animals (McDowell, 1985; Khan *et al.*, 2005). Variations in the contents of Fe observed among grazing forages could partly be explained by forage species differences and the variation in Fe contents of the soil. All the grazing pasture forages had levels of Fe higher than the critical levels of Fe in animal tissues (30-50 mg kg^{-1} DM). Forage Fe levels during the study season were sufficient for the requirements of ruminants for optimal performance. These levels of forage Fe in the present study may support the findings of some earlier reports eg., in Guatemala (Tejada *et al*., 1987), North Florida (Cuesta *et al*., 1993), Nicaragua (Velasquez-Pereira *et al.*, 1997) and Indonesia (Prabowo *et al.*, 1991). High levels of forage Fe found in this study are in agreement with the higher forage Fe value of 650 mg/kg reported earlier by Khan (2003) in a similar region in Pakistan.

Copper: The dietary requirement of ruminants for Cu ranges from 8 to14 mg/kg (Anon., 1984; Khan *et al.*, 2006). Most of the forage samples analyzed in the present study meet the marginal to deficient requirements of this element. This situation may be even further complicated by high levels of dietary Fe which can be elevated by soil ingestion during grazing. Humphries *et al.,* (1981) found that forage Cu concentrations exceeding 1 g/kg can profoundly reduce the availability of ingested Cu. Forage Cu content declines with forage maturity, and is higher in leaf than that in stem (McDowell, 1996). High concentrations of iron (Phillippo *et al.*, 1987) and zinc (Davis & Mertz, 1987) also reduce copper status and may increase copper requirements.

Zinc: Forage Zn concentration was also found above the requirements of ruminants during winter as earlier reported by Reuter & Robinson (1997). It has been suggested that 30 mg/kg Zn is a critical dietary level, although it has been recommended that concentrations of 12-20 mg/kg are adequate for growing ruminants (Anon., 1980). Almost similar results were reported by Prabowo *et al.,* (1991) in South Sulawesi Indonesia and by Tiffany *et al.,* (2001) in North Florida.

Conclusion

This study shows that Na and Cu are present in inadequate amounts for the ruminants in this area. It is stressed that data of the type presented here can provide only an indication of the existence of potential mineral deficiency problems, since animal selectivity usually results in the consumption of material of somewhat higher quality than that of the total available. A conclusive diagnosis must be based on the occurrence of a positive response to supplementary supply of the mineral in question. However, such data are vital in the formulation of critical supplementation experiments. Thus there is an urgent need for appropriate experimentation so that soundly-based supplementation packages can be devised.

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