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SOIL AND FORAGE MINERAL (TRACE ELEMENTS) STATUS OF A GRAZING PASTURE IN THE SEMIARID REGION OF PAKISTAN

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Abstract

A study was conducted to determine the trace mineral status of forage and soils on a goat ranch in the semi-arid region of south western Punjab, Pakistan. Forage and soil samples were collected twice a year during winter and summer from three different sites within the ranch. Site I represented land characterized by natural pasture with low intensity forage accessible to animals. Site II represented land site within proximity of main experimental station where small ruminants were provided hay, crop wastes and also by-products. Site III was grazing reserves characterized by the availability of sown pastures including different improved forage varieties. Seven composite samples from each of the three grazing sites of the pasture were collected during each sampling. Higher forage values of Cu and Mn were found in winter than those during summer. However, Fe and Zn were higher in summer. In general, higher trace elements values were found in grazing site II. Of all forage trace minerals, only Mn was adequate. Concentrations of Cu, Fe and Zn in forage from all three grazing sites during both seasons were below the critical level. All soil elements were higher in grazing sites III than those in other grazing sites. Concentrations below the critical level were found for soil Cu during both seasons in grazing site II and during summer in site I, and for Mn in both seasons in all sites within the pasture.

Introduction

Poor animal growth and reproductive problems are common even when forage supply is adequate, and can be directly related to mineral deficiencies caused by the low mineral concentrations in soils and associated forages (McDowell, 1997). In fact, forage alone rarely can meet all the mineral requirements for grazing animals (McDowell, 1992).

Analysis of soils and forages for mineral composition is important for obtaining mineral status of an area with a view to provide mineral supplements to grazing animals. Adequate information on soil characteristics and mineral composition of forages in the province of Punjab is lacking despite the importance of this region to livestock production.

Many other studies have been conducted in different regions of the world on dry matter yield, nutritive value and persistence of different forages for animals, but very little information is available in the literature on the effect of some management practices on their mineral concentrations, especially on trace elements (Faria-Mamol *et al.*, 1997). Mineral concentrations in forage vary widely among species, and are influenced by many soil and other factors including growth stage, plant part, climate and fertilizer application (Minson, 1990). Mineral deficiencies or imbalances in soils and forages have long been held responsible for low production and reproduction problems among grazing animals (McDowell, 1985). In some countries a number of diseases severely inhibit animal production, with mineral deficiencies and imbalances suggested as at least part of the etiology of these conditions (McDowell, 1987).

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The objectives of this study were to evaluate whether or not different seasons could influence the trace mineral concentrations of soil and forage in three different regions of a grazing pasture in the semiarid region of Pakistan.

Materials and Methods

An investigation was conducted for one year at Livestock Experimental Station Rakh Khaire Wala located in District Layyah, Punjab Pakistan. Soil and forage samples were collected from three different grazing sites within the farm during the winter and summer seasons of the year 2003. Site I represented land characterized by natural pasture with low intensity forage accessible to animals. Site II represented land site within proximity of main experimental station where small ruminants were provided hay, crop wastes and also by-products. Site III was grazing reserves characterized by the availability of sown pastures including different improved forage varieties. Each composite soil and forage sample consisted of 10 sub-samples randomly collected throughout the field. At each sub-sample site, a 10-cm deep soil core was taken with an Oaka field punch and placed in a labeled plastic bag. A 5-cm^2 sample of forage was clipped by hand and placed in a labeled paper bag. The soil sub-samples were air-dried, thoroughly mixed, and sieved to 2mm, and an aliquot was taken for analysis. The unwashed forage samples were dried at 60 ^oC, mixed and ground in a Wiley mill (1-mm sieve), and an aliquot was taken for analyses.

Soil samples were analyzed for Cu, Fe, Mn and Zn according to the standard procedures described by Rhue & Kidder (1983). Minerals were extracted from soil using Mehlich I extraction solution method (0.05 N HCl + 0.025 N H_2SO_4). Forage samples were processed according to the methods of Fick *et al*., (1979) and were analyzed for Cu, Fe, Mn and Zn as with the soil samples. All the elements were determined by atomic absorption spectrophotometer (Anon., 1980). Data obtained for all minerals were statistically analyzed using the SAS statistical package (Anon., 1987; Snedecor & Cochran, 1980).

Results and Discussion

Soil: Sample collection sites differences were observed for all soil mineral concentrations in both summer and winter (Table 1). Seasonal differences were observed only for Cu in site I, with highest concentration in winter. Of all the regions, the site III showed the highest Cu concentrations in summer. Mean soil Cu levels below critical value of 0.3 mg/kg (Rhue & Kidder, 1983) were observed during summer in site I and in summer and winter in site II. Higher values of soil Cu had already been reported elsewhere (Mooso, 1982). Soils with less than 0.6 mg/kg extractable Cu are considered deficient for pasture and other crops (Horowitz & Dantaz, 1973). Result from this study showed higher soil Cu than those found in Florida (Tiffany *et al.*, 1999) and lower than those reported by Cuesta *et al*., (1993). Based on guidelines offered by Rhue & Kidder (1983), the soil of the pasture is low in extractable Cu and thus crops should respond to Cu–fertilizer addition. Without Cu fertilizer addition, we might expect Cu deficient forages.

Soil Fe concentration was high in site III during summer. No seasonal differences were observed in soil Fe for any of the sites. Mean Fe values were generally high compared to critical level of 2.5 mg/kg (Viets & Lindsay, 1973). Soil Fe showed sample collection site effects during both winter and summer seasons, and it was higher in site III during both seasons than those in other sites. However, soil Fe was found to be higher during summer than that during winter. The soil Fe values were found to be lower than those reported in earlier studies (Tejada *et al.,* 1987; Prabowo *et al.*, 1991; Pastrana *et al.*, 1991; Velasquez Pereira *et al.*, 1997; McDowell *et al.*, 1999). In contrast, higher soil Fe values than that in this study have also been reported by Mooso (1982) and Merkel *et al*., (1990).

Table 1. Soil minerals contents as related to seasons and collection sites.

Element	Season	Site I	Site II	Site III	SE
Cu mg/kg	Winter	0.350***	0.128**	0.354*	0.053
	Summer	0.089***	0.095**	0.037*	0.053
Fe mg/kg	Winter	5.77***	3.52**	8.70*	1.34
	Summer	6.09**	5.58**	1015*	1.34
Mn mg/kg	Winter	1.02**	2.67*	3.40*	0.47
	Summer	0.88**	1.82**	3.22*	0.47
Zn mg/kg	Winter	0.77**	2.01**	4.42**	0.6
	Summer	0.70**	1.24**	4.37*	0.6

*, **, *** = Significant at 0.05, 0.01, 0.001 levels.

Soil manganese was high in site III in summer. In winter, site III was higher in soil Mn than site I, but similar to region II. Mean soil Mn values observed were below the critical level of 5 mg/kg (Rhue & Kidder, 1983). Extractable soil Mn differed significantly among the sites during both seasons. Soil Mn was relatively high in site III in both seasons. The soil Mn as found in present study was lower than that reported by Tejada *et al*., (1987) in Guatemala, and Tiffany *et al*., (1998, 1999, 2001) in Florida. This soil has lower than adequate Mn. Thus, plants grown there must have experienced inadequate Mn (Rhue & Kidder, 1983). Soil Mn concentrations were found below the critical levels in all sites of the pasture. The similar low levels of soil Mn have already been reported by Mooso (1982). Even though soil Mn was low, it apparently was adequate since forage concentrations of the mineral were adequate.

Sample collection site III had higher soil Zn content in both seasons. Mean soil Zn values below the critical level of 0.5 mg/kg (Sanchez, 1976) for normal plant growth were found in summer and winter in site I and in summer in site II. Differences in extractable soil Zn were significant among collection sites for either season. Relatively high soil Zn levels were found in site III during both seasons and lowest in site I compared to the other sites. These values were lower than those already reported by Prabowo *et al*., (1991) in Indonesia. Evaluation of soil samples based on critical level of 1 mg/kg for normal plant growth (Rhue & Kidder, 1983) indicated the deficiency of Zn during both the seasons in site I. Soil Zn as found in the present investigation was higher than those reported earlier (Tiffany *et al.*, 1998, 1999, 2000, 2001; Cuesta *et al.,* 1993).

Forage: Mean forage mineral concentrations of the three sample collection sites are presented in Table 2. No collection site effect was observed on forage mineral concentrations except for Cu. Seasonal differences were observed for Fe and Zn. Forage Zn showed site effect only in feeding site II and III during both seasons and exhibited deficiencies in Zn concentration based on dietary requirement of 30 mg/kg suggested by

Table 2. Forage minerals contents as related to seasons and collection sites.

Element	Season	Site I	Site II	Site III	SE
Cu mg/kg	Winter	4.4*	2.9*	4.2*	0.4
	Summer	2.8**	3.6*	4.2*	0.4
Fe mg/kg	Winter	37.3**	36.6***	47.6***	1.7
	Summer	42.6***	49.1***	42.0***	1.7
Mn mg/kg	Winter	54.6	55.8	66.0	6.2
	Summer	48.4	60.2	38.6	6.2
Zn mg/kg	Winter	16.6	13.8***	11.0***	1.8
	Summer	17.7	20.6***	22.2***	1.8

*, **, *** = Significant at 0.05, 0.01, 0.001 levels.

McDowell *et al.*, (1982). However, Zn levels in forage were slightly higher during summer than those during winter in all collection sites. Lower than those for age Zn were reported in Guatemala (Tejada *et al.*, 1987; Tiffany *et al.*, 1999, 1998), higher than those reported in Nicaragua (Velasquez Pereira *et al.*, 1997), and similar to those found in different countries (McDowell *et al.*, 1989; Ogebe & Ayoade, 1995; Pastrana *et al.*, 1991; Tiffany *et al.*, 2001, Rojas *et al.*, 1993) were observed in the present study.

There was a marked sample collection site effect on forage Cu during both seasons, and in all the sites its concentration was below the critical level suggested by McDowell *et al.*, (1984). Higher concentration of forage Cu had already been reported in Nicaragua (Velasquez Pereira *et al.*, 1997) than that found in the present study.

Mean forage Cu concentrations were low during summer in site I and during winter in site II. Forage Cu values were all below the critical level (8 mg/kg). Similar values had also been reported by Merkel *et al.*, (1990) in north Florida. McDowell *et al.*, (1992) reported higher values for the winter and summer seasons. High concentrations of Mo and S interfere with Cu absorption. A Cu-Mo ratio in forage of 2.0 or greater is desirable to a avoid molybdenosis (Ward *et al.*, 1978).

Forage Fe concentrations found in the present study were lower than those found in Guatemala (Tejada *et al.*, 1987) and Florida (Tiffany *et al.*, 1998; 1999, 2000, 2001; Velasquez Pereira *et al.*, 1997). Individual evaluation of samples based on Fe requirements of 30 mg/kg (McDowell *et al.*, 1984) indicated that no forage samples were deficient in Fe. Fe content in forages during both the winter and summer seasons was generally adequate.

Forage Fe concentrations varied among sites of sample collection in both seasons. All mean forage Fe concentrations observed were below the critical level of 50 mg/kg. McDowell *et al.*, (1982) reported mean values ranging from 127 mg/kg to 130 mg/kg for winter and summer seasons, respectively. Similar normal values were also reported by Merkel *et al.*, (1990). Iron deficiency is rare in grazing animals due to a generally adequate content in forages (McDowell *et al.*, 1984), but under certain conditions, Fe deficiency in cattle grazing on sandy soils has been reported (Becker *et al.*, 1965).

Forage Mn was almost similar in all sites during both seasons. Evaluation of samples based on a dietary Mn requirement of 40 mg/kg (McDowell *et al.*, 1984) indicated a small number of forage samples deficient in Mn during summer only in locality III. Forage Mn levels were not parallel to soil Mn levels, since in all sites Mn was deficient in both seasons. Mn concentration in forage was found to be higher than those reported earlier (Prabowo *et al.*, 1991) and lower than those reported by McDowell *et al.*, (1989), Ogebe & Ayoade (1995), and Tiffany *et al*., (1999, 2001). All Mn values, except those in summer in region III, were adequate according to the critical value of 40 mg/kg (McDowell, 1985). Higher concentrations of Mn in forage were reported by McDowell *et al*., (1982) and Merkel *et al*., (1990) in Florida.

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