Pak. J. Bot., 36(3): 635-640, 2004.

SEASONAL VARIATION IN SOIL AND FORAGE MINERAL CONCENTRATIONS IN SEMIARID REGION OF PAKISTAN

ZAFAR IQBAL KHAN, ALTAF HUSSAIN, M. ASHRAF, EHSAN ELAHI VALEEM[*1], M. Y. ASHRAF[**] AND MUHAMMAD SAEED AKHTAR

Department of Botany,
University of Agriculture, Faisalabad, Pakistan.

Abstract

The rationale for this study was to determine soil and forage mineral concentrations as affected by season and location of collection with regard to satisfying grazing sheep nutrient requirements. Forages and soil samples were collected fortnightly during winter and summer seasons from three grazing areas within the same farm. Forages and soils (for soils only extractable nutrients) were analyzed for calcium (Ca) magnesium (Mg), potassium (K), and sodium (Na). It was found that location of collection of forages had little effect on Ca, Na or K forage concentrations, but forage Mg was high in location II during the summer season. In general, all sites of collection were associated with soils with adequate Ca and Mg concentrations, while soil with Na and K were uniformly low. In relation to grazing sheep requirements, all regions were generally adequate with forage levels of Ca, Mg and K, however, Na was deficient in both soil and forage in all locations except Na in soil in location III during summer.

Introduction

Assessment of mineral status of grazing animals involves sampling of forage consumed by animals and soil upon which the forage grows. A sample of greatest value from soil and forage depends on minerals in question (McDowell, 1983). A number of very sensitive methods of analysis have been developed that enable to determine the mineral content in soil and forage samples prepared in various ways. In Pakistan, staple forages for ruminants are mostly native and improved grasses. Poor animal growth and reproductive problems are common even when forage supply is adequate, and can be directly related to mineral deficiencies caused by low mineral concentration in soils and associated forages (McDowell, 1997; Tiffany *et al.*, 2000).

As grazing livestock may not receive mineral supplementations except for common salt they must depend upon forages for their requirements, only rarely can forages completely satisfy all mineral requirements (McDowell *et al.*, 1983, 1984; McDowell, 2003). The health and degree of productivity of livestock are dependent on balanced and adequate quantities of all the necessary nutrients to meet their requirements for a given physiological stage (Youssef *et al.*, 1999). For grazing ruminant livestock, which obtain all or most of the nutrients required from forages, knowledge of the nutrient composition of such forages is therefore essential. The objective of this study was to evaluate seasonal concentrations of macro-minerals in soils and forages under grazing conditions to establish mineral deficiencies and excesses over a two-seasonal grazing period in central Pakistan.

[*1]Sindh Education Management & Information System/Research Monitoring & Evaluation System, Sindh Secretariat, Education & Literacy Department, Government of Sindh, Karachi, Pakistan.
[**]Nuclear Institute for Agriculture and Biology (NIAB) Faisalabad, Pakistan.
(E-mail: valeem786@hotmail.com).

Materials and Methods

Soil and forage samples were collected from three different locations within the grazing sheep pasture at Livestock Experimental Station, Govt. of Pakistan in the semiarid regions of southern Punjab, Pakistan during winter and summer seasons. Collections were made fortnightly during each season. Sampling periods spanned from January to March and June to July during winter and summer, respectively. Each of the composite soil and forage samples for each grazing site came from five sub-samples. Although the soil and forage samples collected during the two seasons did not come from exactly the same spot, they came from the same grazing area of the farm. Forage and soil samples were collected at the same time and site, and principal native and improved forage species in the pasture in which the experimental animals grazed were hand plucked after careful observation for the sheep grazing pattern. Pasture was grazed all the year-round by Thalibreed of sheep. These animals were with variable degrees of cross breeding.

Soil samples were collected using a stainless steel sampling auger at a depth of 15–20 cm. Samples were collected in plastic bags, dried at 60°C for 48h, ground and passed through a 2-mm sieve. Forage samples were clipped with stainless steel scissors and consequently, these samples were packed into paper bags and dried at 60°C for 48h. Forage samples were then ground using a Wiley mill with a 1-mm steel sieve. Ground forage samples were stored in plastic bags until analyzed. Soil samples were analyzed for Ca, Mg, K and Na, and these minerals were extracted using the Mehlich I extracting solution method (0.05*N* HCl + 0.025*N* H_2SO_4 following Rhue & Kidder (1983), while forage samples were prepared and analyzed for mineral concentrations following the methods described by Fick *et al.,* (1979). Elemental concentrations in the extractants were determined by the atomic absorption spectrophotometry (Perkin-Elmer Corp, 1980).

Data obtained in the present study were statistically analyzed using a completely randomized design, and means were compared using Duncan’s Multiple Range test (Snedecor & Cochran, 1980).

Results and Discussion

Soil: There was little variation in soil Ca concentrations among the locations in each sampling season, and in all locations soil Ca concentrations changed little during both seasons. The location III soils had highest Ca concentrations of in winter and summer. Adams & Hartzog (1980) suggested that the critical level Mehlich I extractable Ca is 250 mg/kg and all samples analyzed exceeded this level. Higher levels of soil Ca may increase forage Ca, but no crop yield response would be expected for soil Ca above 250 mg/kg (Adams & Hartzog, 1980). These values of soil Ca were higher than those already reported by Tiffany *et al*., (2000) in North Florida and lower than those reported by Tejada *et al*., (1987) in Guatemala and Ogebe *et al*., (1995) in North Florida.

Similar to the other soil macro-minerals, there was very little variation in soil Mg concentrations due to time or region. None of the locations showed decrease from the critical level at either sampling seasons, but in location II it was higher than locations I and III during the winter sampling and lower during summer sampling. All zonal means were above the critical level of 30 mg/kg as suggested by Hanlon *et al.,* (1990), which is considered adequate for Mg required by plants.

Table 1. Soil macro-minerals as related to season and location of collection.

Element mg/kg	Critical* value	Seasons	Locations		
			I	II	III
Ca^{2+}	250	Winter	419	380	484
		Summer	441	369	514
Mg^{2+}	30	Winter	42	67	34
		Summer	46	31	46
K^{+}	60	Winter	45	34	54
		Summer	48	38	70
Na^{+}	62	Winter	60	41.5	44.4
		Summer	57.3	51.5	72

*Critical concentration (mg/kg): Ca = 250 (Adams & Hartzog, 1980), Mg = 30 (Hanlon *et al.*, 1990), K = 60 (Hanlon *et al.*, 1990), Na = 62 (Rhue & Kidder, 1983)

Soil extractable K concentrations less than 60 mg kg^{-1} are below the critical level, and K fertilizer may result in a growth response (Hanlon *et al.*, 1990). Using this as a criterion, all locations were uniformly low at both sampling times, with the exception of region III that had a concentration of 70 mg/kg that was higher than the critical level during summer sampling and considered adequate for normal plant growth. Although low, these results were generally higher than those reported by Cuesta *et al*., (1993) in North Florida. Plant age generally has a greater influence on forage K than soil K concentrations; young plants are high in K and decline with advancing (McDowell, 1992).

Soil Na values ranged from 44.4 mg/kg to 60 mg/kg during winter and 51.5 mg/kg to 72 mg/kg during summer. Soils were deficient in Na in all locations during winter and in location I and II during summer season. A higher concentration of Na in soil taken from location III during summer was observed as compared to other locations. Sodium deficiencies existed in all locations during winter and location I and II during summer. Nearly all the soil samples in all locations except II during summer were below the critical level of 62 mg/kg (Rhue & Kidder, 1983; Sanchez, 1981). Similar level of soil Na has earlier been reported in Guatemala (Tejada *et al.*, 1987) and in North Florida (Cuesta *et al.*, 1993).

Total soil elemental composition is widely recognized as a poor predictor of bioavailability of soil minerals to plants. The rationale for using the Mehlich I soil test relates to plant response (growth or yield), not mineral bioavailability. Soil fertility tests, such as Mehlich I, are most often used as tools to identify soil deficiencies and to predict the fertility needs of plants. These tests are calibrated so the results can be related to a positive response by a crop to some applied nutrient, however, there is great variation among plant species and soils and “critical” values may not apply to any specific forage. Hanlon *et al.*, (1990) suggested that the benefits of a soil testing and fertilizing system include adequate, but not excessive, fertilization that creates an environment for optimum growth without pollution and soil tests help identify nutrients needed to enhance plant nutrition.

Forage: Mean forage Ca concentrations did not vary among locations for the summer sampling times. Forage Ca from location III was higher than those from locations I and II during winter and forage from all the locations had slightly greater Ca concentrations than the critical level in this season. 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. In view of NRC (1996) Ca requirement for growing and finishing animals expected to grow at 0.89 kg d^{-1} is 0.35% DM. All locations means were above this critical level for both sampling seasons, but remained at marginally deficient level only during summer. Similar low forage Ca concentrations in grasses from Florida were reported (Espinosa *et al.*, 1991; Cuesta *et al*., 1993; Ogebe *et al*., 1995). Higher than these values of forage Ca were reported by Tiffany *et al*., (1999) in Florida.

Magnesium concentrations were well above the critical level of 0.20% (McDowell *et al.*, 1984) during both seasons. Magnesium concentrations for all locations in the present study were higher than those reported previously by Cuesta *et al*., (1993) in north Florida, Tejada *et al*., (1987) in Guatemala and similar to those values found by Tiffany *et al.,* (2000) in Florida.

Table 2. Forage macro-minerals as related to season and location of collection.

Element % d. wt. basis	Critical* value	Seasons	Locations I	Locations II	Locations III
Ca^{2+}	0.35	Winter	0.36	0.43	0.49
		Summer	0.35	0.36	0.38
Mg^{2+}	0.20	Winter	0.39	0.48	0.47
		Summer	0.64	0.83	0.52
K^{+}	0.60, 0.80	Winter	1.00	1.19	1.25
		Summer	4.74	3.98	3.59
Na^{+}	0.06	Winter	0.026	0.027	0.035
		Summer	0.037	0.022	0.025

*Critical concentration (%): Ca, 0.35 (NRC, 1996), Mg 0.20 (McDowell *et al.*, 1984), K, 0.60, 0.80, and Na 0.06 (NRC, 1996)

Concentrations of K were high and adequate for all locations, exceeding the critical level of 0.60% as recommended by the NRC (Anon., 1996) and 0.80% (McDowell *et al.*, 1984) during both seasons. With the exception of location III in summer, there were no location effects evident throughout both the grazing seasons. Results from all the locations were higher in forage K than those found previously by Espinoza *et al.*, (1991) in central Florida, and Cuesta *et al.,* (1993) in north Florida.

Forage Na concentrations of all locations were well below the critical limit 0.06% (Anon., 1996). Although there were zonal effects at both sampling times, they were small and did not persist with time. Sodium deficiency in the forages is well documented, and the concentrations determined by this study are similar to earlier reports by Salih *et al.*, (1988), Cuesta *et al.,* (1993), Tiffany *et al.,* (2000) in Florida and Ogebe *et al.,* (1995) in Nigeria.

In general, all sites of collection were associated with soils with adequate Ca and Mg concentrations, while soil with Na and K were uniformly low. In relation to grazing sheep requirements, all regions were generally adequate with forage levels of Ca, Mg and

K, however, Na was deficient in both soil and forage in all locations except Na in soil in location III during summer.

References

Adams, F. and D.L. Hartzog. 1980. The nature of yield responses of Florunner peanuts to lime. *Peanut Sci.,* 7: 120-123.

Anonymous. 1980. *Analytical Methods for Atomic Absorption Spectrophotometry*. Perkin-Elmer Corp., Norwalk, CT.

Anonymous. 1996. Nutrient requirements of domestic animals (No.4). Nutrient Requirements of Beef Cattle. 6^{th} rev. ed. National Research Council (NRC), National Academy of Science Press, Washington, DC.

Cuesta, P.A., L.R. McDowell, W.E. Kunkle, F. Bullock, A. Drew, N.S. Wilkinson and F.G. Martin. 1993. Seasonal variation of soil and forage mineral concentrations in north Florida. *Commun. Soil Sci. Plant Anal.,* 24: 335-347.

Espinoza, J.E., L.R. McDowell, N.S. Wilkinson, J.H. Conrad, and F.G. Martin. 1991. Monthly variation of forage and soil minerals in central Florida. I. Micronutrients. *Commun. Soil Sci. Plant Anal.,* 22: 1123-1136.

Fick, K.R., L.R. McDowell, P.H. Miles, N.S. Wilkinson, J.D. Funk and J.H. Conrad. 1979. *Methods of Mineral Analysis for Plant and Animal Tissues*. 2nd ed. Animal Science Department, University of Florida, Gainesville, FL.

Hanlon, E.A., G. Kidder, and B.L. McNeal. 1990. Soil, Container Media and Water Testing: Interpretations and IFAS Standardized Fertilization Recommendations. Circular 817. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL.

McDowell, L.R. 1992*. Minerals in Animal and Human Nutrition*. Academic Press, Inc., San Diego, CA.

McDowell, L.R. 1997. *Minerals for Grazing Ruminants in Tropical Regions*. Extension Bulletin, Department of Animal Science, Center for Tropical Agriculture, University of Florida, Gainesville, FL.

McDowell, L.R. 2003. *Minerals in Animal and Human Nutrition* (2^{nd} Ed.). Uni. Florida Gainesville.

McDowell, L.R., J.M. Conrad and G.L. Ellis. 1984. Mineral deficiencies and imbalances and their diagnosis, pp 67-88. In: *Symosium on Herbivore Nutrition in Sub Tropics and Tropics*. (Eds.): F.M.C. Gilchrist and R I Mackie. University of Pretoria, Pretoria, South Africa.

McDowell, L.R., J.M. Conrad, G.L. Ellis and J.K. Loosli. 1983. *Minerals for grazing ruminants in tropical regions*. Extension Bulletin, Animal Science Department, University of Florida, Gainesville, FL.

Ogebe, P.O., J.A. Ayoade, L.R. McDowell, N.S. Wilkinson, and F.G. Martin. 1995. Mineral concentrations of forages and soils in Benue State, Nigeria Macrominerals and forage *in vitro* organic matter digestibility and crude protein concentrations. *Comm. Soil. Sci. Plant Anal*., 26: 1989-2007.

Rhue, R.D. and D. Kidder. 1983. *Analytical procedures used by the IFAS extension soil testing laboratory and the interpretation of the results*. Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL.

Sanchez, P.A. 1981. *Suelos del Tropico. Characteristicas y manejo*. IICA, San Jose, Costa Rica.

Salih, Y., L.R. McDowell, J.F. Hentges, R.M. Mason Jr. and C.J. Wilcox. 1988. Effect of mineral supplementation on grazing Brahman cattle I. Macrominerals. *Int. J. Anim. Sci*., 3: 195-204.

Snedecor, G.W. and W.G. Cochran. 1980. *Statistical Methods* (Sixth Edition) The Iowa State Univ. Press, Ames, IA.

Tejada, R., L.R. McDowell, F.G. Martin and J.H. Conrad. 1987. Evaluation of cattle trace mineralstatus in specific regions of Guatemala. *Trop. Agric*., 64: 55-60.

Tiffany, M.E., L.R. McDowell, G.A. O'Connor, H. Nguyen, F.G. Martin, N.S. Wilkinson and E.C. Cardoso. 2000. Effects of pasture applied biosolids on forage and soil concentrations over a grazing season in north Florida. I. Macrominerals. Crude Protein and *In Vitro* Digestibility. *Commun. Soil Sci. Plant Anal*., 31: 201-203.

Youssef, F.G., L.R. Mcdowell and R.A.I. Brathwaite. 1999. The status of certain trace minerals and sulphur of some tropical grasses in Trinidad. *Trop. Agric*., 76: 57-62.

(Received for publication 14 April 2004)