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ASSESSMENT OF CHROMIUM CONCENTRATIONS IN SOIL-PLANT-ANIMAL CONTINUUM: POSSIBLE RISK FOR GRAZING CATTLE

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Abstract

The present study was conducted to examine the chromium (Cr) status of soil, forage and lactating cows at Livestock Experimental Station, Khizerabad, Sargodha, Pakistan. Samples of soil, forage, blood plasma and milk were collected periodically with a regular interval of one month each and subjected to acid digestion to assess the influence of the sampling intervals on Cr as well as the transfer of this element from soil to forage and onwards to animal during the whole experimentation period. The Cr contents of soil and forage were severely deficient in relation to the requirement for forage and ruminant growth and development, whereas that of blood plasma and milk was marginal deficient level. Supplementing the deficient levels of Cr with locally available feed resources and mineral mixtures having high availability of this element would alleviate the deficiency of chromium in the animal ranch.

Introduction

Appraisal of mineral status of grazing ruminants/livestock primarily involves sampling of forages fed to animals and soil used for growing these forage plants. A sample is of greatest value from soil, plant and tissues of animal in question and also depends upon the mineral to be determined from these variables (McDowell, 1985). Since the soil, plant and animal system is very intricate so it has not been thoroughly examined in many developing countries including Pakistan. Thus, gaining information on the status and interrelationships of inorganic minerals in the afore-mentioned system is vital for achieving maximal livestock productivity.

The forage plants under specific conditions may absorb toxic metals from soil as well as from metal deposits on the surfaces of plant parts exposed to a polluted environment. Furthermore, fertilizers containing heavy metals is an additional source of metal pollution for forage plants. Regardless of all this, trace amounts of some metals like copper, cobalt, zinc, manganese and chromium are essentially required for a normal animal and plant growth (Tokalioglu *et al*., 2000; Bratakos *et al*., 2002). Chromium (Cr) is a trace element that is most commonly found in nature in the three and six oxidation states, and the latter form of Cr is an oxidizing mineral which is employed in most of the processes related to industry. Like many other metals, it also plays an important role in the metabolism of living organisms (Tokalioglu *et al*., 2000; Tokaliglu & Kartal, 2005). Chromium has been considered as an essential trace element for man and laboratory animals (Anon., 1997), because it plays a variety of roles in the metabolisms of both animals and plants (McDowell, 2003). Regardless of a substantial role of Cr in various physiological processes in ruminants, the information on Cr availability to animals is

very limited. Chromium concentration for livestock requirement ranges from 0.3 to 1.6 mg/kg which is generally higher than the available Cr to livestock (Anon., 1997). Chromium levels higher than these values are toxic to livestock and it badly affects the reproductive potential of ruminants (McDowell, 2003; McDowell & Arthington, 2005).

Keeping in view the importance of this element to livestock, the premier aim of the present investigation was to authenticate the practicability of broad feeding pattern for free grazing ruminants rather than appraising the actual daily Cr ingestion for animals.

Materials and Methods

The study was conducted during 2008-2009 at Khizer Abad Livestock Experimental Station, located in central Punjab, district Sargodha, Pakistan. The detailed description of this site has been given elsewhere (Khan *et al*., 2010). Although about 5000 animals are being nurtured at the station, the number of Sahiwal breed cows is 1208.

Soil, forage, milk and blood samples were collected four times each with one month interval during winter to assess the variation in the mineral concentrations during transfer of the metal from soil to plants (forage) and onwards to animals during the study period. Soil and forage samples were collected randomly from 5 different sites within the pasture at regular intervals of one month each during the research period (winter season). The soil samples were collected from 15 to 20 cm depth. All soil and forage samples were oven-dried at appropriate temperatures until constant dry weights. The major forage species recorded at the pasture during winter were *Medicago sativa* and *Trifolium alexandrinum*, and the minor species *Brassica campestris, Cichorium intybus*, and *Avena sativa*. After proper drying, the plant and soil samples were ground well and made to powder.

Twenty each of clinically healthy lactating cows of Sahiwal breed in their second lactation, with average body weight of 315 kg were investigated for the study purpose. The experimental animals were allowed to graze in the pasture whole day daily. The forage and blood samples of lactating cattle were collected concurrently when soil and forage sampling was done, from this ranch with one month interval.

Milk samples were also collected from these cows for the analysis of chromium. These milk samples were then homogenized and preserved in plastic disposable bottles and frozen at -20^{o}C.Blood plasma was harvested by centrifugation at 3000 rpm for 15-30 min. Plasma was separated. Plasma samples were put into clean labeled polypropylene vessels and frozen at -20 ◦C.

One g soil and 0.5 g forage dried and ground samples were digested in a mixture of H_2SO_4 and H_2O_2 at high temperatures. After the digestion of both types of samples was complete they were made to desired volumes with double distilled water.

A sample of 1 ml of each of blood plasma or milk was taken in a conical flask and dried slowly at 150^{o}C for 30 min. After drying, all samples were digested with H_2SO_4 and H_2O_2 in 1:2 ratio. After completing digestion the clear solution was filtered and the volume was made up to 50 ml by adding double distilled water.

The concentrations of chromium in soil and forage were determined using an atomic absorption spectrophotometer (Model #AA-6300, Shimadzu, Japan). For the analysis of chromium from the plasma samples atomic absorption spectrophotometer coupled with a graphite furnace was used (AA-6300 & GFAEXi7i, Shimadzu, Japan).

Statistical analysis: Data for Cr content of different types of samples were analyzed statistically using the SPSS software. A one-way analysis of variance (ANOVA) of each variable was worked out. Furthermore, correlations among soil, forage, plasma and milk Cr contents were also calculated using the SAS software.

Results and Discussion

Chromium is one of the important trace elements involved in animal growth and development (Parish & Rhinehart, 2008). Although improvement in growth performance and immune response in stressed cattle has been reported with Cr supplementation, beef cattle producers do not normally use chromium supplementation under normal conditions (Parish & Rhinehart, 2008). Furthermore, chromium is far more abundant in soil than in crops (Underwood & Suttle, 1999).

Analysis of variance shows that sampling intervals had non- significant effect on soil Cr levels (Table 1). Soil Cr ranged from 0.006 to 0.007 mg/kg during the entire study period. Low amount of Cr was found at the 3rd sampling interval (December) and high at the 4th sampling interval (January) (Fig. 1). Soil Cr content reported during our study is lower than that reported in some earlier studies (Hodgson, 1990).

The effect of sampling intervals on forage Cr levels was found to be non- significant (Table 1). It ranged from 0.0022 to 0.0028 mg/kg throughout all sampling intervals. There was a consistent increase in forage Cr content with sampling time. Higher value of Cr was found at the 4th sampling interval (January), but lower at the 1st sampling (October) (Fig. 1). The concentration of forage Cr reported in our study is considerably higher than that reported earlier by Ahmed *et al*. (2008). It has been reported that different plant parts contain variable amount of Cr (Anderson *et al*., 1990). All forage samples in our study area had low level of Cr which is not toxic for animals being reared at the farm.

Sampling intervals had no significant effect on plasma Cr level (Table 1). The highest blood Cr concentration was found at the 2nd sampling interval (November) and lowest at the 4th sampling interval (January) (Fig. 1). The values at all sampling intervals ranged from 0.0011 to 0.0016 mg/L during our investigation. Although Cr is an essential nutrient for animals, its intestinal absorption is low with estimated range from 0.522 to 3% in fasting animals (McDowell, 2003). However, increased growth rates have been reported in different animals due to Cr supplementation (Li *et al*., 1986).

A non-significant effect ($p \leq 0.05$) of sampling intervals was observed on milk Cr levels (Table 1). Higher milk Cr levels were observed at the 3rd sampling interval (December) while lower at the 1st sampling interval (October) (Fig. 1). Milk Cr ranged from 0.0003 to 0.0006 mg/L across all samplings. Flynn (1992) reported 0.002 mg/L Cr in milk, but in the present investigation all milk samples showed relatively lower values. The Cr levels reported were found in our investigation lower than those reported earlier by Hurley (1997) while working on milk mineral status of animals in USA.

Correlation among soil, forage, plasma and milk Cr concentrations: The correlations between soil and forage, forage and plasma, and plasma and milk Cr concentrations were calculated. The correlation coefficient (r) between soil and forage Cr was found to be 0.037, forage and plasma -0.25, soil and plasma -0.25, plasma and milk -0.12, soil and milk 0.0007, and forage and milk 0.068. There was a positive and non-significant relationship between soil and forage Cr, negative and significant between soil and plasma, plasma and forage, and plasma and milk Cr levels. While positive and non–significant relationships were found between soil and milk, and milk and plasma Cr concentrations in this investigation. These data show low or no correlations between different variables and in some instances even negative correlation coefficients between different variables have been noted. These findings corroborate with some earlier studies which also exhibited weak or no correlations among different parameters (Mtimuni, 1982; Tejada *et al*., 1987; Songonzoni *et al*., 1997).

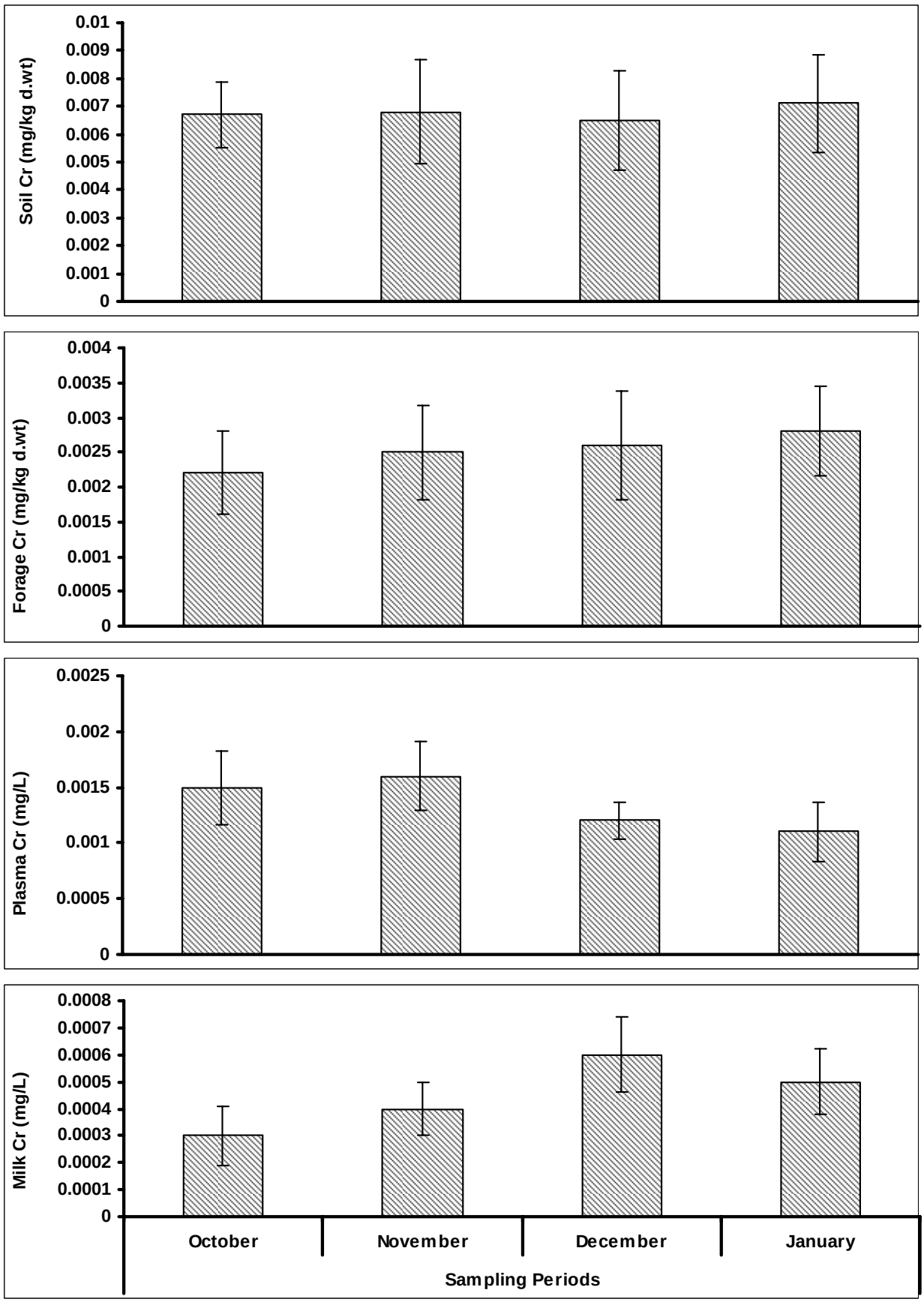

Fig. 1. Concentration of Cr in soil, forage, blood plasma and milk at different sampling intervals.

Table 1. Mean squares from analysis of variance of data for chromium levels in soil, forage, blood plasma, and milk at different sampling intervals.

Source of variation	df	Mean squares			
		Soil	Forage	Blood plasma	Milk
Sampling period	3	0.0003^{ns}	0.0002^{ns}	0.0001^{ns}	0.0004^{ns}
Error	16	0.0001	0.0002	0.0001	0.0004

ns = Non-significant

Conclusions

The results of the present investigation clearly depict that chromium levels were deficient in soil, forage and blood samples reflecting that Cr deficiency is a principal limiting factor for cattle production in this specific area. However, mineral supplementation investigations are required to assess the cost-benefit relationships of the provision of mineral mixtures including Cr supplementation to the grazing ruminants at this specific ranch.

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