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DETERMINATION OF FORAGE CONCENTRATIONS OF LEAD, NICKEL AND CHROMIUM IN RELATION TO THE REQUIREMENTS OF GRAZING RUMINANTS IN THE SALT RANGE, PAKISTAN

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Abstract

Ruminants are of central to livestock production system in Pakistan and for livestock grazing, forage mineral concentration is of considerable importance. The forage concentrations of Pb, Ni and Cr were investigated with respect to the nutrient requirement of the grazing ruminants in the Soone Valley located within the Salt Range, Punjab, Pakistan. Based on the data recorded, it was concluded that the concentration of these three minerals varied among different pastures and even in different plant parts. The Pb concentration in the leaves ranged from 0.034 to 0.069 mg g^{-1} in different pastures, while in pods it ranged from 0.040 to 0.065 mg g^{-1}. The leaf Cr varied from 0.156 to 0.285 mg g^{-1} and in pods it was from 0.166 to 0.223 mg g^{-1}. The leaf Ni concentration ranged from 0.030 to 0.068 and that in pods from 0.037 to 0.084 mg g^{-1}. The concentrations of Pb, Ni and Cr observed in the forage from Salt Range are significantly higher than their critical levels already known in the literature. Thus, these forage may cause toxicosis problems in animals grazing the area.

Introduction

Livestock in general and ruminants in particular are potential source of food. Their growth and health are considerably affected due to malnutrition especially due to the concentration of trace minerals in feed. Plant forage analysis for mineral elements is considered essential for botanical and environmental concerns. The uptake of mineral elements can provide a significant information on plant forage mineral concentrations (Yusuf *et al.,* 2003). Most forage plants absorb most of the minerals and heavy metals from the soil and polluted air. Fertilization practices also are an additional source of metals, particularly heavy metals. Most of the heavy metals have a great concern for livestock due to their toxicosis effects (Tokalioglu *et al.,* 2000).

Of various heavy metals Ni content of feed or food stuff is variable and depends upon the site and species in question (Anke *et al.,* 1983). Ni concentrations in components used in diets for livestock were 1.4% of corn and 0.6% of cotton seed hull (McDowell, 2003). Concentrations of Ni in grasses are generally lower than those in soils but legumes such as Alfalfa contain more Ni (Underwood & Suttle, 1999). In general, plant foods are higher in Ni than foods of animal origin. It has been noticed that with diets very low in Ni, animals have failed to grow, develop and reproduce normally (Nielson, 1996).

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Ni requirement for monogastric species may be between 50 and 200 ppb (Nielson, 1997). Although no formally established biological function of Ni in animals is known, however, some findings indicate that Ni functions either as a co-factor or structural component in specific metalo-enzyme or as a bio-legend (McDowell, 2003). Lead is another important trace element that may enter the body through absorption in the gastro-intestinal tract. Absorption ability of Pb is in the range of 5-15 % (Reichlamayr-Lais & Kirchgessner, 1997). The environmental Pb is largely airborne and returns to soil, water, and plants as dust, and it can become a hazard especially for grazing livestock. Suttle & Brebner (1990) reported that ingestion of soil enriched with Pb may cause a hazard to grazing animals. Chromium is an essential nutrient for animals but is toxic for plants even at very low concentration. Intestinal absorption of trivalent Cr is low with estimates ranging < 0.522 to 3 % in fasted animals (McDowell, 2003). Other function of Cr relates to its effects on growth, lipid metabolism, immune response and interactions with nucleic acids. Increased growth rates have been recorded in various animals due to Cr (Stoecker, 1996). Various plant parts have variable amount of Cr concentration (Anderson *et al.,* 1990). Legumes may contain more Cr than most other foods (McDowell, 2003).

Keeping in view the importance of the nutritive elements for animals grazing in the Soone Valley of Punjab, Pakistan, the study was executed to assess the critical values below which deficiency or above which toxicity of the elements take place. The information gathered could be useful for successful management of grazing livestock with similar ecological conditions where forages are the sole source of mineral nutrition for animals.

Materials and Methods

The experimental site selected was the Soone Valley, which lies in the heart of the Salt Range. The Valley climate is characterized by a relatively low annual precipitation (508 mm). The minimum temperature during winter is 1ºC, while average maximum temperature is 36ºC during summer. Hot dry winds and prolonged periods of drought are frequent and winters quite often experience frost. Summer and winter both are cooler than those of the neighbouring plains and the winter season is also longer than that in plains (Hussain, 2002; Ahmad *et al*., 2007). Vegetation of Soone Valley was ecologically studied during 2005 to explore the micro-mineral contents of forage plants to assess the mineral needs of grazing livestock met by the forage species. The six feeding sites or pastures within the Valley were selected for sampling purpose. The pastures were away from each another at a distance of 5 km. The pastures or feeding sites were designated as Pasture A, B, C, D, E & F, respectively. These native pastures are found with dominated leguminous plant species (*Acacia farnesiana, Acacia modesta, Acacia nilotica, Medicago denticulata, Melilotus indica, Sophora mollis, Lathyrus aphaca* and *Vicia sativa*) and grasses (*Cynodon dactylon, Saccharum munja, Saccharum spontaneum* and *Cyperus rotundus*), which make up the bulk of herbaceous cover. Native pastures are the major sources of feed for different ruminants in the valley.

Sample collection: During the survey, grazing animals were followed and forage samples corresponding to those consumed by the ruminants were collected from each pasture. Five samples of different forage species, predominant in each pasture, were taken four times after an interval of three months. Each sample comprised of five sub-samples of each plant species. Green leaves and pods of all available leguminous species were used for analytical work. The procedures followed are described below:

Table 1. Mean forage concentrations (mg g^{-1} dry weight) of Pb, Cr, and Ni in relation to different pastures of Soone Valley, Punjab, Pakistan.

Pasture type	Pb		Cr		Ni	
	Leaves	Pods	Leaves	Pods	Leaves	Pods
A	0.034 ± 0.006	0.042 ± 0.016	0.158 ± 0.053	0.166 ± 0.046	0.030 ± 0.008	0.062 ± 0.019
B	0.040 ± 0.009	0.041 ± 0.009	0.156 ± 0.032	0.200 ± 0.028	0.038 ± 0.009	0.061 ± 0.011
C	0.037 ± 0.012	0.065 ± 0.009	0.208 ± 0.075	0.207 ± 0.072	0.068 ± 0.010	0.072 ± 0.010
D	0.037 ± 0.008	0.040 ± 0.010	0.159 ± 0.033	0.223 ± 0.058	0.050 ± 0.012	0.037 ± 0.013
E	0.045 ± 0.010	0.050 ± 0.005	0.285 ± 0.091	0.203 ± 0.039	0.047 ± 0.010	0.078 ± 0.017
F	0.069 ± 0.016	0.043 ± 0.013	0.216 ± 0.056	0.223 ± 0.048	0.050 ± 0.015	0.084 ± 0.018

Critical values for Pb = 0.00005-0.003, Ni = 0.00005-0.005.0 and Cr = 0.00005-0.0005 mg g^{-1} as suggested by Tokalioglu *et al*., (2000)

Digestion: Dried ground material (0.5 g) was taken in digestion tubes and added 5 mL of concentrated H_2SO_4, incubated it overnight at room temperature. Then ½ mL of H_2O_2 (35%) was poured down the sides of the digestion tube, ported the tubes in a digestion block and heated at 350º C until fumes were produced and continued to heat for another 30 minutes. The digestion tubes were removed from the block and cooled. Then slowly added ½ mL H_2O_2 and placed the tubes back into the digestion block. The above step was repeated until the cooled digested material became colourless. The volume of the extract was maintained up to 50 mL in volumetric flasks. The extract was filtered and used for analysis.

Analysis of ions: Lead (Pb), chromium (Cr) and nickel (Ni) concentrations in the digests were determined by an atomic absorption spectrophotometer (Anon., 1980).

Statistical analysis: The data collected were analyzed by analysis of variance technique. Duncan's New Multiple Range test at 5% level of probability was used to test the differences between the mean values (Steel & Torrie, 1986).

Results and Discussion

Mean mineral concentrations of forages in relation to pastures are presented in Table 1. Some elements like Pb, Cd, Hg, Ni and Al are frequently classified as toxic elements, widely distributed in air, feed, water and soil. Mineral toxicities are more difficult to control than deficiency especially under grazing conditions. Mean forage Pb contents varied from 0.034 mg/g to 0.069 mg/g in the leaves and from 0.040 mg/g to 0.065 mg/g in pods of different forage species. Higher ($p \leq 0.05$) Pb values were observed in leaves of forage plants collected from pasture-F, while lower ($p \leq 0.05$) Pb values were found in the leaves of plants from pasture-A and pods of plants from pasture-D. Mean forage Pb concentrations were higher than the critical values of typical plants as suggested by Tokalioglu & Kartal (2005).

The maximum Ni concentrations were found in the leaves (0.068 mg/g) of plants collected from pasture-C, while the minimum value (0.030 mg/g) was recorded for plants in pasture-A. As far as Ni concentration in pods is concerned, the maximum value (0.084 mg/g) was found in plants from pasture-F and the minimum level (0.037 mg/g) in the pods of forages collected from pasture-D. The values recorded for Ni were above toxic levels suggested for typical plants (Tokalioglu & Kartal, 2005). In pasture-E, the maximum Cr concentration (0.285 mg/g) was recorded in the leaves and the minimum (0.156 mg/g) in pasture-B. The Cr concentration in pods is also influenced by pasture forage species and plant parts and it was 0.223 mg/g in pasture-F and 0.166 mg/g in pasture-A in the pods of plants collected from those pastures.

The Pb, Ni and Cr metals are very dangerous for livestock health if these are present in the dietary sources at a greater level than the admissible ones reported by the Consumer Regulatory Authority. In our present investigations, fodder/forage consumed by the animals in this specific Salt Range had high quantity of these metals, which might have accumulated in the bodies of grazing animals thereby causing different health problems like hyperkeratosis, colour changes in skin, bone defects, fracture and kidney and nervous system damage (McDowell, 2003). The general possible eating of contaminated edible tissues of food animals like cattle, goat and sheep in the area under study may cause the excessive accumulation of these heavy metals. This scenario thus will pose a threat to public health. Therefore, this study emphasizes the essentiality of further investigations to determine the levels of heavy metals in different tissues and fluids of grazing animals in this Valley so that the public may be familiarized with disastrous health problems. However, some specific measures should be taken in order to safe-guard the livestock reared in this area from the toxic effects of these metals.

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