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EVALUATION OF MACRO-MINERAL CONCENTRATIONS OF FORAGES IN RELATION TO RUMINANTS REQUIREMENTS: A CASE STUDY IN SOONE VALLEY, PUNJAB, PAKISTAN

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Abstract

This manuscript reports the essential macro-mineral composition of different plant species in the Soone Valley located in the Salt Range within the province of Punjab, Pakistan. The climate of this Range is characterized by a relatively low annual rainfall (508 mm) and temperature varying from 1° C to 36° C in winter and summer, respectively. Hot dry winds and prolonged periods of drought are frequent in the Range. Grazing animals were followed and forage plants consumed by the livestock, were collected during the study period in the year 2004. The forage plants consisted of legumes and grasses. Different plant parts such as leaves, leaflets and pods, which were lavishly grazed by the grazing animals were separated and analyzed for macro-minerals, Na, P, K, Ca and Mg. On the basis of observations it can be concluded that most of the forage samples were sufficient in Na, P, K, Ca and Mg for the requirements of ruminants grazing therein. Comparatively, the macro-mineral concentrations in pods were higher than those found in the leaves and leaflets showing no need of mineral supplementation. However, it seems most interesting to elucidate the phenomenon of antagonism among minerals, which may adversely affect the availability of minerals in the bodies of animals.

Introduction

The endurance and physical condition of plants depend on the regular supply of mineral nutrients from the soil. It has been suggested that the species with higher P and K in their leaves are more productive and more beneficial for livestock, because these elements are equally very important for livestock (Ashraf *et al.,* 1992; Irigoyen *et al.,* 1992). Calcium and Mg are also useful for livestock because both of these elements are essential for normal growth of livestock (Walker, 1980; Underwood, 1981; Aregheore & Hunter, 1999; Khan *et al.*, 2004a). Simple problems like muscle cramps and spasms emerge in animals due to deficiency of Ca, Mg and other electrolytes. Digestive enzyme production in animals is impaired if minerals are not sufficiently available. The balance of minerals is of vital consideration for animal health so far as their availability and assimilation is concerned. The body can tolerate a deficiency of vitamins longer than a deficiency of minerals (Grunes & Welch, 1989).

The naturally available forage species, grasses and legumes in the Soone Valley experience harsh environmental conditions such as marked seasonal temperature fluctuation, very low annual rainfall, dry winds and grazing pressure. Thus, under such stressful environments it is naive to expect considerable variation in the contents of essential nutrients in the forage species inhabiting the site as compared to those growing under normal edaphic and climatic conditions.

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The present study was therefore undertaken to explore nutrient contents of plant forages available in the Soone Valley located in the Salt Range, Pakistan in order to have knowledge of critical levels for grazing livestock and formulation of supplementation regimes if needed to the animals rearing in the Valley.

Materials and Methods

The Salt Range is situated between longitude 71º30′ and 73º30′ E and between the parallels of 32º23′ and 33º N latitude. The average height of the Range is about, 676.92 m above sea level. The Soone Valley lies in the heart of the Salt Range. The climate of the Valley is characterized by a relatively low annual rainfall (508 mm) and average minimum temperature is 1º C (January) while average maximum temperature 36º C (June). Hot dry winds and prolonged periods of drought are the important characteristics of the Valley (Hussain, 2002).

Forage sample collection: Survey of Soone Valley, district Khushab in the Punjab province of Pakistan, was conducted to explore the forage species indigenous to it. Six different types of meadows were assigned for forage collection. All the meadows in the Valley are natural.

Five representative forage samples were collected thrice from each meadow during the study year. The forage samples both grazed and browsed were collected by clipping with a steel scissors. Most dominant forage plants in the Soone Valley were *Adhatoda vasica, Achyranthus aspara, Capparis aphylla, Dodonea viscose, Buxus papilosa, Zizyphus mauritiana, Olea ferruginea, Zizyphus nimularia, Salvadora oleoides, Gymnosporea royleana, Tecomella undulate, Tamarix aphylla* and *Nerium indicum* along with some grasses i.e., *Cynodon dactylon, Cyperus rotundus, Pennisetum cenchroides,* and *Digitaria bicornis.* Following most dominant forage legumes like *Acacia farnesiana, Acacia modesta, Dalbergia sissoo, Medicago polymorpha, Melilotus indica* and *Vicia sativa* were found on more than 50 % on the study sites. Most abundantly grazed forages consisting of both legumes and grasses were selected for the estimation of the role of plant nutrients in livestock production.

Plant samples (green leaves, leaflets and pods) of all available species were collected from the selected six meadows and all plant forages were analysed separately. The data of leaves and pods of different species were pooled to assess the macro-mineral levels in relation to the requirement of ruminants grazing therein. The procedures followed are described below:

Digestion: Dried ground material (0.5 g) was taken in digestion tubes and 5 mL of concentrated H_2SO_4 added and incubated overnight at room temperature. Then the tubes were placed in a digestion block and heated at 350º C until the plant material was completely digested. The volume of the extract was made up to 50 mL and the extract was filtered and used for analysis.

Analysis of ions: The sodium (Na^+), potassium (K^+), and calcium (Ca^{++}) contents were analyzed with a flame photometer. Magnesium (Mg^{++}) was analyzed on an atomic absorption spectrophotometer. Phosphorus (P) was analyzed on a spectrophotometer. The extracted material (2 mL) was dissolved in 2 mL of Barton reagent and total volume was made 50 mL. The samples were kept for half an hour before analyzing phosphorus. The Barton reagent was prepared as described by Jackson (1962).

Barton reagent: Solution A: 25 g of ammonium molybdate was dissolved in 400 mL of distilled water. Solution B: Ammonium metavandate (1.25 g) was dissolved in 300 mL of boiling water then cooled and 250 mL of concentrated HNO_3 was added and cooled again at room temperature. The solutions A and B were mixed and the volume was maintained up to one liter and stored at room temperature. Data were analyzed using the procedures as described by Steel & Torrie (1980).

Results and Discussion

The forage macro-mineral concentrations of different forages from six meadows are presented in Table 1. In the leaves Na^+ levels ranged from 4.32 to 5.67 mg/g and from 3.45 to 4.39 mg/g in the pods of forage species. The highest value of Na^+ was found in the pods of forages collected from meadow-B and the lowest value in the leaves of forages from meadow-D. Mean plant Na^+ levels were sufficiently higher than the critical levels established by NRC (Anon., 1984). The higher values of Na^+ in the forage plants were in disagreement with those found in literature (Espinoza *et al*., 1991; Pastrana *et al*., 1991; Ogebe *et al*., 1995; Khan *et al*., 2005; 2006a; 2007). Mean plant P values ranged from 15.82 to 28.59 mg/g in the leaves and from 20.05 to 29.97 mg/g in the pods of various plant species. Pod P concentrations were higher in plants from meadow-B and the lower in the leaves of forage plants from meadow-F. Overall, P levels in both leaves and pods were generally above the critical levels suggested for ruminants (Anon., 1984). Similar levels of plant P have already been reported in Florida (McDowell *et al*., 1982; Merkel *et al*., 1990; Espinoza *et al*., 1991) and in Guatemala (Tejada *et al*., 1985; 1987).
Potassium (K) in different species varied from 12.45 to 17.23 mg/g in leaves and 8.15 to 11.10 mg/g in pods. Lowest values of K^+ were observed in the leaves of forages from meadow-E and highest in the pods of forages from meadow-F. Concentrations of K^+ in plants from all meadows were not enough but were at marginal deficient levels for the requirements of grazing livestock according to the critical levels established by Mayland *et al*., (1980). Concentrations of K^+ may occasionally fluctuate in plants, but this concentration declines rapidly as plants mature (Mayland *et al*., 1987; Espinoza *et al*., 1991; Khan *et al*., 2004b). Similar values of plant K^+ were reported in Florida (Espinoza *et al*., 1991; Tiffany *et al*., 2001) and in Pakistan (Khan *et al*., 2006b).

Plant Mg^{2+} concentrations ranged from 2.59-4.38 mg/g in the leaves of different forages evaluated and from 2.49 to 4.14 mg/g in the pods. Highest Mg concentration was found in the pods of forages collected from meadow-F and the lowest value in the leaves of forages from meadow-D. Mg concentrations in plants from all meadows were higher enough than the critical levels for ruminants as suggested by NRC (Anon., 1984). High plant Mg concentration found presently is in disagreement with the values found previously (Reuter & Robinson, 1997; Espinoza *et al*., 1991; Khan *et al.*, 2005; 2006a; 2007).

Mean Ca^{++} levels ranged from 3.07 to 4.41 mg/g in the leaves of various forage species and from 3.96 to 11.78 mg/g in pods of same species. The highest value of Ca^{++} was found in pods of forages collected from meadow-A and the lowest value in the leaves of forages collected from meadow-E. Mean plant Ca^{++} levels were sufficiently higher than the critical levels established by NRC (Anon., 1984) for the requirements of ruminants. These higher values of Ca^{++} in the forage plants were in disagreement with those found in the literature (Espinoza *et al*., 1991; Pastrana *et al*., 1991; Ogebe *et al*., 1995; Khan *et al*., 2005, 2006a, 2007).

Table 1. Macro-mineral concentrations (Mean ± S.E.) of forages collected from different meadows in the Soone Valley of Punjab, Pakistan.

Mineral concentration (mg/g d.wt.)	Meadow type					
	A	B	C	D	E	F
Na^+ in leaves	5.08±0.42	5.67±0.26	4.60±0.47	4.32±0.48	4.71±0.38	5.23±0.42
Na^+ in pods	3.58±0.66	4.39±0.40	4.18±0.48	3.45±0.37	4.35±0.25	3.92±0.46
P in leaves	21.86±1.08	28.59±1.35	21.61±0.62	22.59±0.78	20.15±1.12	15.82±0.84
P in pods	20.05±0.76	29.97±2.68	26.20±1.38	26.60±0.79	24.92±1.17	29.61±2.34
K^+ in leaves	17.23±1.20	15.91±1.10	13.34±0.78	14.78±0.71	12.45±0.88	14.29±0.99
K^+ in pods	9.10±1.04	9.71±0.61	8.15±0.80	10.76±0.93	10.32±0.55	11.10±1.30
Mg^{++} in leaves	4.38±0.65	2.90±0.12	3.05±0.08	2.59±0.19	3.21±0.24	3.18±0.19
Mg^{++} in pods	3.62±0.56	2.63±0.32	2.49±0.60	3.62±0.46	2.67±0.17	4.14±0.39
Ca^{++} in leaves	4.41±0.68	4.12±0.40	4.16±0.29	3.68±0.42	3.07±0.17	3.90±0.20
Ca^{++} in pods	11.78±1.19	9.39±0.80	4.55±0.91	3.96±0.67	4.43±0.46	4.36±0.70

It is concluded that macro-mineral concentrations in various plants examined were found to be sufficient for the needs of livestock in this range and there is no need of supplementation. However, further investigation is required to identify that these macro-minerals are meeting the demands of animals, as there are many interactions among minerals in the animal bodies. Mineral concentrations vary significantly among species ranging from toxic to inadequate for livestock production. In the present studies major elements were analyzed in all meadows to demonstrate their palatability and nutritive value for grazing animals. Sodium, phosphorus, potassium, magnesium, and calcium are essential elements and involved in most of the metabolic activities of the plants and animals. Almost all the species possessed high values of these elements in leaves as well as in pods. High contents of all macro-minerals of forages found in this study may have been due to the soil chemical composition and better absorbing capability of forage plants for these elements.

From all above discussion it can be concluded that the plant species assessed in the present investigation are palatable and contain reasonable amount of macro-nutrients for livestock grazing in this specific Valley and there is no urgent need for supplementation as these elements are sufficient for ruminants requirements.

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