ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Macro-mineral status of soil, feed and animal in Chhattisgarh state (India)

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Manuscript Info

Manuscript History:

Received: 29 March 2014
Final Accepted: 25 April 2014
Published Online: May 2014

Key words:
Chhattisgarh, Jamunapari, Macro-mineral

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Abstract

The plains, plateau and hills of Chhattisgarh region was chosen for evaluating the macro mineral status of goats during the rainy and dry season in terms of mineral concentrations in soils, feeds, blood plasma and faeces on rural and urban farms. Soil samples were collected from entire Chhattisgarh region and were analysed for Ca, P, Mg, Na and K. Blood samples from graded Jammunapari and local desi non-descript goats were collected for analysis of Ca, P, Mg and K elements. Both the blood and bone samples were collected during the rainy and dry season for finding out the seasonal differences. The results indicated wide variation in the concentrations of minerals of different areas of the state. Available feeds in the area consist of pasture, hay, and rice straws, wheat, local grass, berseem, maize and jowar. Pasture grass and other feeds were found to be deficient in Na, P and Mg in relation to dietary requirements. The analysis of blood plasma for graded Jammunapari does revealed that during rainy season the Ca, P, Mg and K levels were 11.22, 4.73, 2.88 and 15.88 mg/100 ml, respectively. Whereas during dry season the same were 14.66, 5.22, 2.88 and 16.44 mg/100 ml, respectively. Results suggested significant ($P<0.01$) differences in macro elements between rainy and dry seasons. Also there were significant difference between macro elements level ($P<0.01$) in does and kids was found. Faecal analysis revealed that about 80 per cent of the animals were deficient in Na. Blood plasma of local desi non-descript does revealed during rainy season for Ca, P, Mg and K were 11.22, 5.66, 2.66 and 17.77 mg/100 ml, respectively. Whereas during dry season they were 13.44, 6.00, 3.00 and 16.44 mg/100 ml, respectively. Results suggested significant ($P<0.01$) differences in macro elements between rainy and dry seasons. Also there was significant differences between macro elements level ($P<0.01$) in does and kids. Wide variations in the minerals content of soils and lack of significant correlations among soil, pasture and blood plasma indicated that soil and pasture analyses are not reliable in assessing macro mineral status of grazing goat in this environment. Analyses of bone and blood for Ca and P, blood for Mg and faeces for Na appeared to provide better indices.

Introduction

Chhattisgarh is predominantly a mono-cropped state with paddy being the main crop, cultivated in the $3/5^{th}$ of the total area during kharif season (Ramarao et al., 2006). The byproducts obtained are rice bran and rice polish as the concentrate and some of the roughage are meant for the feeding of livestock. The rice straw is the poor source of energy, fermentable nitrogen, minerals and vitamins, which limits the availability of nutrients for

increasing livestock productivity. All plants and animals depend ultimately upon the soil for their mineral nutrients. With plants this relationship is direct and is simplified by the fact that the plant is stationary. The only natural sources of minerals for our animals are forages and sometimes through passive intake of soil. Investigations carried out during the last half century have shown that many of the nutritional maladies results from the inability of the soils of the affected area to supply, through the plants that grow upon them, the minerals need of man and his domestic animals in adequate, safe, or non toxic amounts and in proper proportions. Pasture management, season and to some extend soil nutrient status, can affect herbage macro mineral composition (Gizachew and Smith, 2012).

Minerals unlike other nutrients cannot be synthesized by living organisms. Every living cell depends upon minerals for proper structure and functions. Out of twenty two believed essential mineral elements for animal kingdom, seven are macro and fifteen are micro minerals. For ruminants atleast sixteen mineral elements are generally considered as either nutritionally essential or as a problem in excessive concentration. There are seven major or macro (Ca, P, K, Na, Cl, Mg, S) and eight trace or micro (Fe, I, Zn, Cu, Co, Mn, Mo, Se) minerals (McDowell and Conrad, 1990). Mineral imbalances are frequently encountered in tropical countries (Prasad et al., 1995) and most naturally occurring mineral deficiencies in cattle are region specific (McDowell, 1996Poor drainage conditions often increases extractable trace elements (Cu, Co, Mn, Fe), thereby increase uptake by plants (Grace and Clark, 1991). Soil minerals status may be reflected in plants in respect of certain minerals, but not in others. Because, plant minerals is affected by factor such as yield, genetic differences, chemical from of minerals in the soil, pH, degree of aeration and water logging on the land. Plant concentration of minerals is better correlated with dilute acid extracts of minerals from the soil in respect of iodine, cobalt etc. However, a 'plant available' mineral of the soil is more correlated with plant growth and not necessarily plant concentration regarding several other minerals.

The varying agro climatic conditions, topography and soil type of Chhattisgarh provide good vegetation for grazing livestock as well as an excellent source of ores. These ores are utilized by the industries for extraction of minerals and the effluents may add its effect in disturbing the soil, water, plant and animal ecosystem. The ores as such may be deficient in one, toxic in other or adequate in some other minerals required for normal functioning and growth of plants and animals. The toxic, deficient or imbalanced minerals of such soil may interact with each other and aggravate the condition of their inadequacy in plants due to their poor uptake. The plants and other vegetation grown in such agro climatic zones may differ from the other parts of the country, limiting the availability of minerals due to livestock and reflecting the production performance of animals and therefore, the socio economic status of the poor farmers. By keeping the above facts in view the present study was planned to evaluate the levels of Macro (Ca, P, Mg, Na and K) minerals in soil, plants and animals.

Materials and Methods

The experiment was carried out in the different agroclimatic zone of Chhattisgarh region identified as hill, plain and plateau containing 16 districts.

Hill-Korea, Surguja, Jashpur

Plain-Kawardha, Bilaspur, Kanker, Durg, Raipur, Mahasamund, Dhamtari, Raigarh, Korba, Janjgir-Champa, Rajnandgaon,

Plateau- Jagdalpur, Dantewada

The study was carried out on randomly selected rural and urban areas. Samples of soil, forage, concentrate, blood were collected towards the end of the rainy and dry season. The available feeds were pasture, hay, different types of straws and grains of maize, jowar, oats and small millets from small farms of local non-descript goats.

Sample collection

Samples of soil and pasture grass were collected from each district of Chhattisgarh where animals were grazing, and pooled. The samples were taken during the dry as well as rainy season. During rainy season pasture is the main source of feed. A soil sampling drill was used to sample the top 20 cm of soil. Representative samples of pasture were collected from grazing land and were dried in a forced draught oven at 90-10^{o}C. Samples of rice straws, local grass, berseem and as well as the grains of maize, jowar and other small millets were collected during the dry season from the targeted areas. The blood samples were collected randomly from local non-descript goats from different rural and urban areas. These samples were collected by jugular puncture in vacutainers (10 ml) containing heparin as an anticoagulant and prepared for analysis. Faecal samples were also collected for the analysis of minerals. Faecal samples were dried in a hot air oven at 90-100^{o}C. Fresh bone samples of local breed were collected from local slaughter house and prepared for analysis.

Chemical analysis

Soil samples were analysed for pH, organic matter (OM), Ca, P, Mg, Na and K. Soil OM was determined according to the method of AOAC (1984). Except for P, macro minerals were extracted from soil with 1 N ammonium acetate. Minerals were then determined by using an atomic absorption spectrophotometer (ECIL – ElementAS AAS 4141). Phosphorus was extracted from the samples with 0.1 N HCl and NH_4F and was determined in a UV spectrophotometer (Safas Monaco, Model : Uvmc^4). Dry matter (DM) in feeds and faeces was determined by drying samples at 105^{O}C for 12 h. Ash was determined after combustion at 550^{O}C for 6h.

Results and Discussion

Soil

The mean soil Ca was 4100.87 ppm (Table 1). Soil P was low on most of the farms. There were wide variations within all macro element concentrations correlation between soil Ca and Mg with pH was significant ($P<0.01$).

Feed

The mean concentrations of minerals in the feeds are presented in Table 2. Pasture grass samples showed lower Ca with mean values of 0.53% of DM. Pasture samples showed contents of P to (0.33%), Na (0.01%) and K (2.01%). The level of Mg was found to be (0.24%). Straws were found to be low in P and Mg, while grains of maize, jowar, oats and small millets were deficient in Ca and Mg. All feeds were extremely low in Na. There were wide variations in Ca, P, Mg. and K contents of forages. There were no correlations above 0.5 between forage and soil minerals.

Blood

Blood plasma mineral concentrations for different goat breeds and age and the overall mean are presented in Table 3. The overall mean blood plasma Ca was significantly ($P<0.01$) lower in the rainy season than the dry season. Significant effect was found for breed ($P<0.01$), but the effect of age was not significant. The overall mean plasma P concentration was significantly ($P<0.01$) lower. Plasma K was affected only by age ($P<0.01$). There were no relationships between the blood plasma and soil minerals on the one hand and blood plasma and pasture on the other.

Faeces

Faecal Ca contents were ($P<0.01$) higher (Table 4). The level of K in faecal contents of all the minerals and ash was presented in the table 4. Apart from Na, seasonal effects ($P<0.01$) were also found for all the faecal minerals and ash. Of the faecal minerals, age had a significant ($P<0.05$) effect only on Na.

Bone

Mean bone ash (Table 5) was lower ($P<0.05$) in samples collected during the rainy season than the dry season (60.77 *vs.* 65.33). There were no difference between seasons in fat free bone Ca (33.66 *vs*. 33.00) and P (18.33 *vs.* 19.11). The bone samples collected during the rainy season contained significantly ($P<0.05$) less Mg than those collected in the dry season (0.33 *vs.* 0.44).

Table 1: Macro-mineral content and pH of soil sample collected during rainy season

Particulars	Mean	Standard Deviation
Ca (ppm)	4100.87	1710.34
P (ppm)	10.62	16.18
Mg (ppm)	768.03	247.59
Na (ppm)	41.46	28.77
K (ppm)	368.13	239.41

pH	5.30	0.31

Table 2: Macro-mineral content of pasture, different types of straws and grains (% of DM)

Particulars	Pasture		Rice straw		Rice straw+Berseem		Oat straw		Local grass		Grains	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Ca (%)	053	0.20	0.21	0.58	0.51	0.13	0.15	0.07	0.21	0.04	0.07	0.03
P (%)	0.33	0.12	0.16	0.05	0.20	0.08	0.12	0.03	0.08	0.03	0.40	0.05
Mg (%)	0.24	0.04	0.10	0.03	0.27	0.05	0.10	0.04	0.14	0.02	0.13	0.02
Na (%)	0.01	0.01	0.03	0.02	1.73	0.57	0.02	0.01	0.03	0.01	0.01	0.00
K (%)	2.01	0.88	1.26	0.39	1.73	0.56	1.28	0.31	0.89	0.23	0.51	0.15

Table 3: Macro-mineral concentration (mg/100 ml) of blood plasma collected from goats during rainy and dry season

Particulars	Season	Graded Jamunapari				Nondescript				Overall	
		Doe		Kid		Doe		Kid			
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Ca (mg)	Rainy	11.22	1.39	11.55	1.33	11.22	1.32	10.66	1.17	11.16	1.41
	Dry	14.66	2.58	14.44	2.40	13.44	2.36	13.88	2.54	14.11	2.60
P (mg)	Rainy	4.73	2.82	7.00	1.70	5.66	2.83	7.33	1.77	6.18	2.85
	Dry	5.22	1.22	7.22	1.45	6.00	1.39	7.11	1.46	6.39	1.46
Mg(mg)	Rainy	2.88	0.89	2.77	0.83	2.66	0.84	2.77	0.94	2.77	0.92
	Dry	2.88	0.28	2.88	0.89	3.00	0.38	2.88	0.89	2.88	0.76
K (mg)	Rainy	15.88	1.78	18.22	1.87	17.77	2.13	17.11	1.83	17.25	2.00
	Dry	16.44	1.57	18.11	1.37	16.44	1.57	16.77	1.43	16.94	1.56

Table 4: Macro-mineral ,ash (% of DM) content and Na/K ratio of faeces collected during rainy and dry season

Particulars	Season	Graded Jamunapari				Nondescript				Overall	
		Doe		Kid		Doe		Kid			
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Ca (%)	Rainy	2.55	0.64	2.81	0.73	2.24	0.51	2.29	1.60	2.47	1.12
	Dry	1.76	0.29	1.73	0.29	1.80	0.31	1.60	0.22	1.72	0.28
P (%)	Rainy	0.70	0.14	0.80	0.12	0.70	0.14	0.76	0.12	0.74	0.14
	Dry	0.43	0.15	0.43	0.15	0.43	0.14	0.44	0.16	0.43	0.15

Mg(%)	Rainy	0.83	0.06	0.82	0.08	0.74	0.07	0.77	0.11	0.80	0.08
	Dry	0.55	0.05	0.54	0.06	0.55	0.05	0.55	0.06	0.55	0.05
Na (%)	Rainy	0.12	0.06	0.12	0.06	0.12	0.06	0.18	0.23	0.13	0.10
	Dry	0.22	0.07	0.16	0.07	0.07	0.01	0.16	0.07	0.15	0.06
K(%)	Rainy	2.16	0.04	1.82	0.38	2.20	0.04	1.75	0.37	1.98	1.32
	Dry	1.20	0.04	0.89	0.47	1.10	0.05	1.06	0.35	1.06	0.36
Na/K	Rainy	0.05	0.02	0.07	0.05	0.06	0.02	0.10	0.11	0.07	0.04
	Dry	0.18	0.05	0.26	0.22	0.06	0.01	0.18	0.13	0.17	0.18
Ash(%)	Rainy	24.13	4.50	29.17	3.44	30.62	5.26	28.81	3.63	28.18	4.73
	Dry	19.56	2.36	19.01	2.67	19.80	2.43	19.45	2.68	19.45	2.48

Table 5: Analysis of bone collected from goat during rainy and dry season (On %DM basis)

Particulars	Season	Mean	Standard Deviation
Ash(%)	Rainy	60.77	4.13
	Dry	65.33	2.91
Ca (%)	Rainy	33.66	1.85
	Dry	33.00	3.43
P(%)	Rainy	18.33	3.46
	Dry	19.11	3.75
Mg (%)	Rainy	0.33	0.07
	Dry	0.44	0.05

In the present study, the mean pH of soil samples collected was 5.3. Contents of Ca, P, Mg and K were similar to those found by Singh et al (1990), who indicated low P and relatively high K.

Mean concentrations of Ca in pasture grass and hay were higher than the suggested requirement of 0.30% for growing and mature goat (NRC 1981). All three types of straw and grains of maize, jowar, small millets and oats contained less than 0.30% Ca on a dry matter basis. The critical level of Ca in the blood plasma has been suggested to be 8 mg/100ml (Mc Dowell, 1985). In the present study, adequate Ca in the pasture, plasma and bone indicated that Ca deficiency among goat was unlikely.

A dietary level of 0.22 % P has been considered sufficient for small ruminants (Mc Dowell, 1985). Underwood (1981) suggested a dietary P level of 0.17% to be marginal for grazing ruminants. In the present study P content in the pasture and grains exceeded these values. The mean P level in the straws was below 0.25 %. The results indicated that natural pastures in the Chhattisgarh region contain sufficient P.

The mean P concentrations in plasma of graded Jammunapari and local non-descript goats were higher than the suggested critical level of 4.5-mg/100 ml (Mc Dowell, 1985). The concentrations of blood plasma P were found to be below the critical level on more than 20% of the animals. The lower faecal P indicated lower dietary P intake. Another explanation could be that P absorption was reduced due to higher Ca or Fe intake. Calcium and/or Fe have

been found to reduce P absorption from the gastrointestinal tract (Prabow et al., 1989). In the present study faecal Ca was higher. Blood and faecal Fe were also found higher. Although feeds contained high levels of Ca and Fe, soil ingestion could also be a source of these elements. Grazing goats may ingest upto 50gm of soil per day (Desai et al., 1984). Furthermore, when blood samples are taken levels of P in plasma can be biased because blood P levels may increase due to animals stress and excitation.. Mandal et al. (1996) found high concentrations of P in blood serum when the concentration in forage was extremely low. He concluded that the above mentioned factors, which are often difficult to control under practical conditions, altered the P concentration.

Metson et al., (1966) suggested a dietary level of 0.25% Mg in forages to be the lowest safe level for beef goats, while Malewar (1995) proposed 0.20% Mg in forage to be the lowest required level. In the present study, however, high numbers of pasture samples, all straws and grains contained less than 0.20% Mg. Plasma Mg levels of 1.5 to 2 mg/100 ml are considered as safety margin, and animals with less than 1 mg Mg/100ml plasma are exposed to the risk of tetany (Mc Dowell, 1985). When Mg deficiency is severe, it may cause seizures and abnormal heart rhythm (Cox, 2014). The lower plasma Mg in the rainy season compared with the dry season could probably be due to the negative effect of herbage K on Mg absorption (Lall et al., 1996). In the present study, the overall mean faecal K was higher in the rainy season than the dry season, which can be related to the higher K intake from the pasture.

Samples of all the feedstuffs from the study area were shown to be lightly deficient in Na. The recommended level of Na in feeds for growing goats ranges between 0.07 and 0.1% Na in DM (Underwood, 1981). NRC (1981) recommended 0.10 % Na for growing goats and 0.18% for lactating does. The results showed that pastures in Chhattisgarh state do not contain adequate Na for goats. The extremely low Na in the feeds was reflected in a low faecal Na. About 80% of animals were found to suffer from Na deficiency as indicated by faecal Na below the critical level of 1g/kg DM and a Na/K ratio below 0.1 (Ramana et al., 2000). Except for the grains of maize, jowar and oats all the feeds sampled contained levels of K above the critical level of 0.8 % of DM (Underwood, 1981). According to Underwood (1981) K deficiency is unlikely in tropical areas among grazing animals.

Major numbers of animals were found to be deficient in minerals during the rainy season. Grazing animals usually lose their weight during the dry season in the tropical regions and subsequently have lower mineral requirements than during the rainy season. The present results indicate that goats and kids of both local as well as graded Jammunapari suffered mainly from Na and P deficiency. The wide variation in the mineral contents of pastures was in agreement with the results of Leng et al. (1972) whose results indicated that such variations were related to the occurrence of different species of herbage. Furthermore, the problem of soil erosion could also affect the mineral content of pasture grass. Therefore, wide variations in the mineral content of soils and pastures, and lack of significant correlations between soil, pasture and blood plasma indicated that soil and pasture analyses are not reliable in assessing macro mineral status of grazing goats under conditions found in the present study. Analyses of bone and blood for Mg and faeces for Na appear to provide better indices.

Conclusion

The results of survey of macro minerals status of soil, feeds, goat in Chhattisgarh region indicated that wide variations in the content of soil, pasture were found and such variations were related to the occurrence of soil erosion and presence of different species of herbage. Therefore, lack of significant correlation between soil, pasture and blood plasma indicated that soil and pasture analyses in assessing macro mineral status of grazing goats are not useful. Analysis of bone and blood for Mg and faeces for Na appear to provide better indices. So it would be better to interpret the results and applying the appropriate measures to tackle the bottle necks in the area concerned.

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