4.3.2. MINERAL REQUIREMENTS AND STRAW FEEDING SYSTEMS

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INTRODUCTION

Minerals are required in small quantities compared to the nutrients like nitrogen and energy. However, mineral deficiency can have a marked effect on productivity, particularly on reproductive performance and health. Straws and stovers contain certain minerals well below the animals' needs, but they contain an excess of minerals like Silica and in some regions Lead, Selenium and Fluorine, leading to either deficiency or toxicity in animals. Mineral imbalances depend on the type of straw (varieties) and on the area where the straw is grown. Mineral requirements are related to animal output, and therefore, the use of mineral supplements is particularly important for high producing animals. First we will give a classification of minerals, then we will discuss functions, requirements and toxicities. The final part discusses deficiencies and ways of mineral supplementation.

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CLASSIFICATION, FUNCTIONS AND REQUIREMENTS OF MINERALS

It is well established that certain mineral elements perform essential functions in the body, and they must therefore be supplied in the feed. Calcium, Phosphorus, Magnesium and Fluorine are constituents of bones and teeth and give strength to skeletal structures of the body. They are also constituents of soft tissues. Elements such as Calcium, Phosphorus, Magnesium, Iron, Manganese, Copper, Zinc and Selenium play important roles in enzyme systems. Sodium, Potassium and Chlorine function as soluble salts to maintain osmotic pressure, acid base balance and pH in the body fluids in addition to water metabolism. Iron, Copper and Cobalt form vitamin B^{12} through rumen microbes which is later necessary in the formation of Haemoglobin. Iodine is an essential element in a hormone released from the thyroid gland and it functions in many ways in soft tissues. Sulphur occurs in organic compounds, notably in sulphur containing particular amino acids.

REQUIREMENTS

Whilę calculating mineral requirements, it is essential to see the types of feed ingredients that are used in the ration, along with the kind of straws and stovers fed. Feeding of low quality roughage generally results in increased faecal endogenous losses, for example, Ca and P, leading to increased maintenance requirements for these minerals. If the feed ingredients contain anti-metabolites like tannins, phytates, oxalates or silica beyond a particular limit, some minerals like P and Ca have to be supplemented to ensure adequate absorption. Also, the need to supplement may be greater in animals with parasitic infections due to increased mineral requirement. The mineral elements are classified as macro, micro and trace elements, depending on their content in animal tissues and on their biological functions (Table 1).

Table 1. Classification of Minerals

Class	Elements
Macro-Elements	Calcium (Ca), Chlorine (Cl), Potassium (K), Magnesium (Mg), Sodium (Na), Phosphorus (P), Sulphur (S)
Micro-Elements	Copper (Cu), Fluorine (F), Iodine (I), Iron (Fe), Manganese (Mn), Zinc (Zn)
Trace-Elelements	Lead (Pb), Molybdenum (Mo), Cobalt (Co), Chromium (Cr), Nickel (Ni), Selenium (Se), Vanadium (V)

The requirements of Calcium and Phosphorus in high producing dairy animals are higher than in low yielders owing to the high concentration of Calcium (0.13%) and Phosphorus (0.11%) in milk. The Ca:P ratio is important and a ratio of 2:1 to 6:1 seems to be optimum for cattle. The Ca and P requirement for maintenance of an adult cow weighing 40 kg and yielding 10 kg milk with 4 percent fat will be 46 and 36 g, respectively. Mineral requirements for growth, milk production and work for cattle are given in Tables 2a and 2b.

The mineral requirements can be expressed in amounts per day or per unit of product, or as a percentage of the dietary dry matter intake. The former is more accurate but the latter is simple and practical as long as there is no variation in feed intake. Since dry matter intake varies considerably in straws and stovers, the expression in absolute amounts may be more appropriate.

Table 2a. Requirements of Ca and P for maintenance, growth, milk production and work

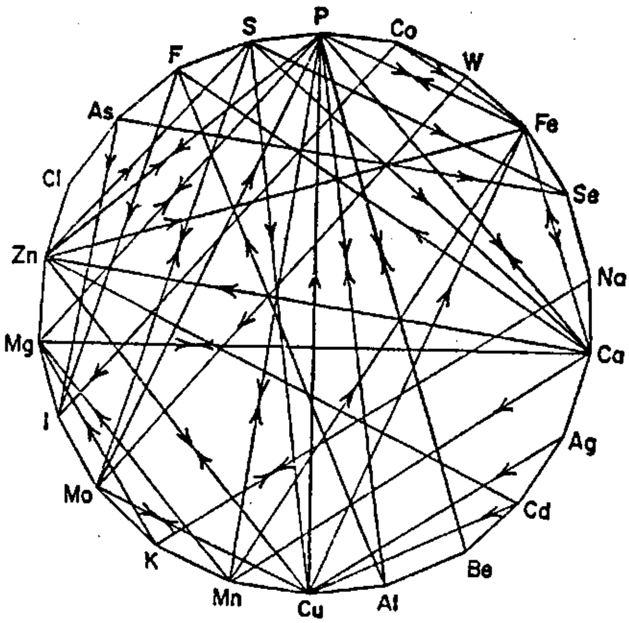
Description of animal	Calcium	Phosphorus
Pre-ruminant calves (% of diet)	0.8	0.5
Growing calves (% of diet)	0.8	0.5
Maintenance of adult animals (400 kg)	18	12
Adult cows (400 kg, 3000 kg milk)	18	14
Pregnant cows* (g/day)	19	19
Milk production (g/day/kg milk)	2.8	2.0
Working bullocks (g/day)	15	15

* In addition to what is provided for maintenance

Table 2b. Requirement of other minerals (mg per kg bodyweight)

Minerals	Young stock	Mature dairy animals
Cobalt	0.1	0.1
Copper	10	10
Iron	100	50
Magnesium	700	2000
Sulphur	2000	2000
Zinc	30	40
Sodium	2500	4600
Potassium	6000-8000	6000-8000

Figure 1. Interrelation of mineral matter in animal metabolism. The arrows indicate synergism and antagonism between elements. (Source: Hafer and Dyer, 1969 (quoted by Banerjee, 1982))



MINERAL INTERACTION

Minerals interact with each other and with other nutrients (Figure 1). Interactions which mutually enhance absorption in the digestive tract and jointly fulfil some metabolic function are termed synergistic. The interactions which inhibit the absorption of two or more minerals and produce opposite effects on a biochemical function are termed antagonistic. These interactions can take place in the feed itself, in the digestive tract and during tissue and cell metabolism. Because minerals tend to form bonds or complexes, they are more liable for interaction than other nutrient substances. Examples of

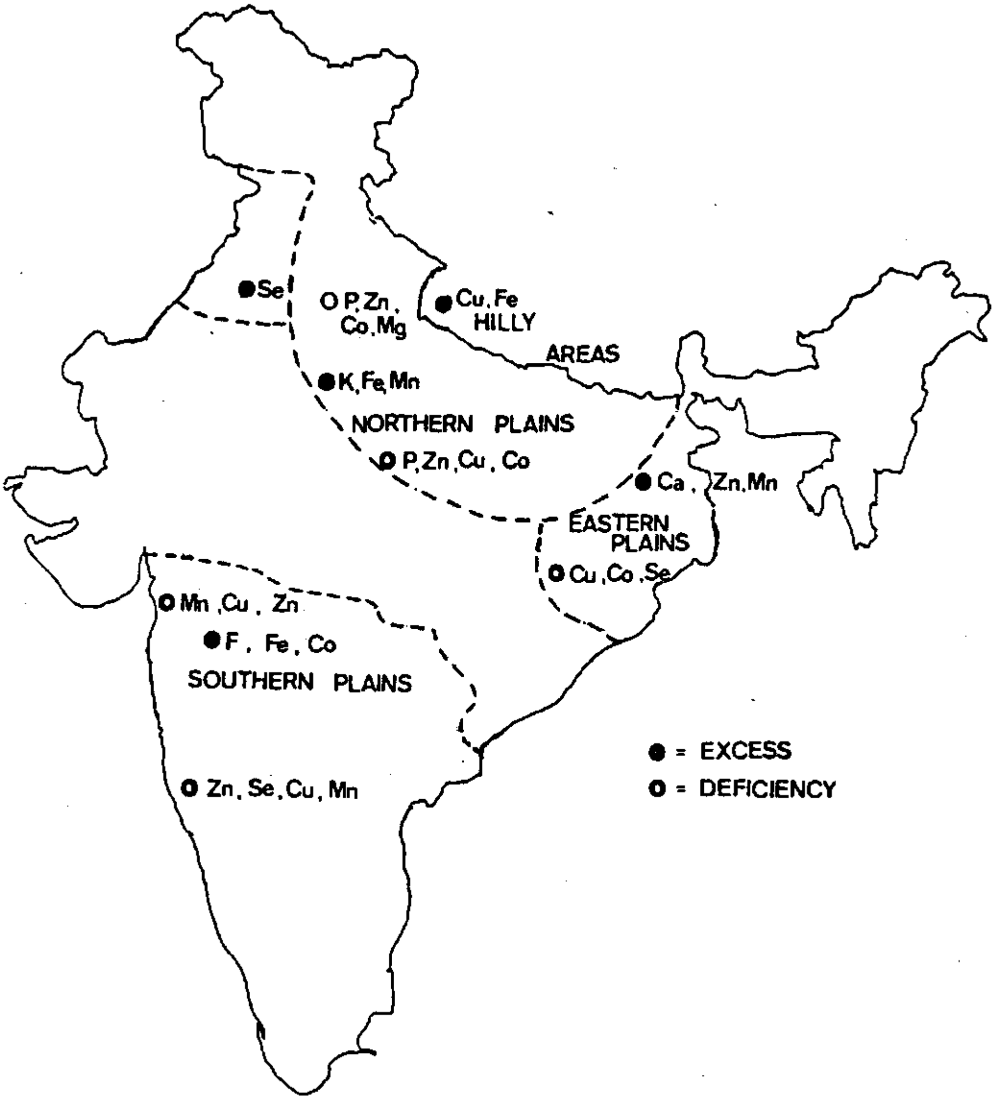
synergistic effect are between Ca and P, Na and Cl, Zn and Mo.
Examples of antagonistic effects are the formation of Magnesium Phosphates in the presence of excess Mg, formation of triple Ca-P-Zn salt in the presence of high Ca and between Cu, Mo and S. The balance between these minerals is therefore an important consideration when fixing up the requirements of animals.

TOXICITY AND DEFICIENCY SYMPTOMS

Based on soil analyses, the areas in India that are likely to be in excess or deficient in minerals are shown in Figure 2. Farm animals are not particularly sensitive to an excess of most of the elements and the mineral levels need to be high before any toxicity symptoms are seen. Peculiar differences are seen between goats and sheep on Cu excess. However, elements like Se, F, Pb and Cd may accumulate in straws and can cause toxicity leading to impaired metabolism and loss in production. In areas of Punjab, Haryana, and Western U. P. there are cases of Selenium excess. It affects the hooves and other extremities. It is popularly known as "Degnala disease", and attributed by some to mycotoxins in the straw.

Some minerals like Ca, P and Zn are stored in body tissues, and their deficiency symptoms will only appear after a period of time. In the case of Calcium and Sodium, deficiencies can be observed more quickly, particularly in high producing milch animals and fast growing young stock. When Ca is deficient, or when the Ca metabolism is upset after parturition, clinical signs of milk fever may develop in high yielding cows.

Figure 2. Map of India showing areas that are likely to be in excess or deficient in minerals, based on soil analysis.



Ca and P deficiency in young growing animals can cause rickets, unsteady walk, lameness and stunted growth. A moderate deficiency of P in the diet may lead to retardation of growth, impairment of bone mineralization and high mortality in young calves. In adult animals, P deficiency may lead to a decrease in live weight and milk yield due to reduced consumption of feed. The animals show reduced appetite and start chewing wood and other objects, a condition termed "Pica". Mg deficiency in adult ruminants causes what is known as 'grass staggers' or 'grass tetany', leading to high nervous excitability, shivering and unsteady walk. This condition results from consuming large quantities of grass on pasture land with imbalanced elements (excess K). In ammonia treated straw it might however show up since a high ammonia concentration in the rumen is reported to impair Mg absorption. It needs to be remembered that feeding of berseem (crude protein content about 20% of dry matter) is likely to produce more ammonia than the feeding of urea treated straws with a crude protein content of around 11% or lower.

In working animals the allowance of minerals like common salt has to be increased due to increased muscular activity. Salt, consisting of Na and Cl, is lost through increased sweating in hot conditions. Salt addition is often claimed to increase palatability, but that is not yet conclusively proven. The deficiency of most of the micro and trace elements indirectly affect animal performance by impaired metabolism. Typical symptoms of mineral deficiency are loss of appetite, rough hair coat, listless appearance and decreased body weight. Deficiencies may, however, not appear until the animals are deprived of the minerals for a long time as the body tries to maintain normal blood levels in spite of deficiency.

The economic losses due to mineral deficiencies could be high depending on the type of animal. It may range from losses caused by delayed maturity of female calves, losses in milk production, low performance of working bullocks and reproductive problems.

SOURCE OF MINERALS

Straws, stovers and other feed ingredients commonly fed to livestock are usually deficient in minerals. Therefore, supplementation of each mineral is necessary, depending on its availability in a particular area and level of desired production. In the absence of survey information, when dealing with high producing animals, it may be necessary to provide mineral mixtures that contain all elements. Animals can be supplemented directly with suitable minerals (Table 3) or with mixtures in boxes or with mineral licks. Calculated quantities can be incorporated in special feeds, e.g. concentrate or urea-molasses lick blocks. When making mineral premixes of licks, attempts must be made to reduce the cost so that the main advantage of feeding low quality roughage is not offset by expensive supplements.

A list of common straws with their mineral content is given in Table 4. Costly mineral supplements that are required in relatively large quantities are Calcium and Phosphorus. In order to reduce this cost, it is possible to supplement with ingredients that are relatively rich in these minerals, e.g., rice bran, wheat bran, rice polish or leguminous fodders. For example, when 8 kg DM treated rice straw was provided to a cow weighing 400 kg and producing 7 litres milk, the daily Ca and P balances were -6 and -21 g respectively, which was reduced to -5 and -4 g per day respectively, when

1 kg bran was supplemented. With 5 kg straw and 5 kg greens and 1 kg rice bran, both the minerals showed a positive balance.

Table 3. Mineral salts used for livestock feeding and their nutrient mineral content in g/kg (CMN, 1973).

	Ca	P	Mg	Na	Cl	Cu	Co	I	Zn	Mn
Dicalcium posphate ($CaHPO_4.2H_2O$)	220	170								
Decalcified bone meal *)	300	130	10							
Chalk ($CaCo_3$)	360									
Monosodium phosphate ($NaH_2PO_4.2H_2O$)		190		150						
Disodium phosphate ($Na_2HPO_4.12H_2O$) **)		80		120						
Dehydrated disodium phosphate		220		320						
Magnesium sulphate ($MgSO_4.7H_2O$)			90							
Magnesium oxide (MgO)			500							
Iodized salt (NaCl)				390	590			0.04		
Copper sulphate ($CuSO_4.5H_2O$)						240				
Cobalt sulphate ($CoSO_4.7H_2O$)							200			
Stabilized iodine preparation (CuI) (10 g/kg)						3		7		
Zinc sulphate ($ZnSO_4.7H_2O$)									210	
Zinc oxide (ZnO)									750	
Manganese sulphate ($MnSO_4.H_2O$)										220
Manganese oxide (MnO)										580

*) Bone meal which is not decalcified can be also considered as a practical Ca and P supplement.
**) Most sodium phosphates contain much water of crystallization and are hygroscopic. forms with little or no water are desirable and a guarantee on the content of phosphorus is useful. A guarantee is also needed that phosphates are sufficiently low in fluorine.

Table 4. Mineral content of different crop residues

Type of Straw	Mineral content (g/kg)				
	Ca	P	Mg	S	Co(ppm)
Rice	21-40	0.05-0.22	0.07-0.25	0.05-0.11	0.081
Wheat	22-42	0.2-1.5	0.08-0.16	0.04-0.10	0.065
Oat	17-36	0.02-0.07	0.11-0.30	0.11-0.30	0.245
Sorghum	8-54	0.10-0.34	*	*	0.205
F. millet	16-30	0.08-0.32	*	0.08-0.11	*

(Source: Ranjhan, 1981; Kearl, 1982)
* not known

Most cereals are rich in Zn, Fe and S, but poor in Ca. Oil cakes are rich in S, Co and are moderate sources of Zn and Cu. All roughage tend to contain less P. Mineral contents of some of the common feed ingredients are given in Table 5. This mineral composition could vary considerably depending upon the fertility status of the soil and/or processing conditions (oil cakes, brans, polish).

Feeding of formulated mineral mixtures, or pure ingredients, can be a simple way to provide deficient minerals if and when they are available. Selection should be on the basis of biological availability, or release and absorption coefficient. For example, dicalcium phosphate is the best Ca and P supplement, derived commercially from bone meal. On the other hand, rock phosphate though a good source of Ca and P, is rich in F, and can cause F toxicity. Biologically, most sulphates and chlorides are more readily available than oxides. The ferrous form of Fe (Fe^{++}) is utilized in tissues and thus better for supplementation than the ferric (Fe^{+++}) form, though the latter can be converted into its Fe^{++} form, in the gastrointestinal tract.

Amongst the chemically prepared salts, orthophosphates are readily available, but meta- and pyrophosphates have limited absorption rates. Calcium as Calcium Silicate is not absorbable.

Table 5. Mineral content of common feed ingredients

Feed Ingredient	Mineral content					
	Ca(%)	P(%)	S(%)	Cu(ppm)	Zn(ppm)	Co(ppm)
Oil Cakes	0.12	0.48	0.40	16.6	34.6	0.4-0.56
Cereal grains	0.07	0.04	0.56	10.9	74.0	0.40
By-products						
Brans	0.14	0.80	*	11.0	76.1	0.10
Rice polish	0.24	0.49	*	13.9	10.9	0.10
Green fodder						
Legumes	1.5-3.0	0.14-0.4	*	12.0	50.0	0.48-0.63
Non-Legumes	0.3-0.4	0.12-0.28	*	9.6	*	0.18-0.39
Grasses	0.2-0.3	0.07-0.3	0.06	10.6	*	*

(Source: Ranjhan, 1981; Underwood, 1981)
* not known

CONCLUSION

Animals on straw based diets are likely to be deficient in P, Mg, S, Cu, Co and Zn. When straw diets are fed, there is a possibility of a negative Ca balance due to the presence of high silica and oxalate (binding). Salt should be provided in the diet and minerals may be provided mixed with the concentrates to dairy animals. Supplementing green fodder and concentrate byproducts like brans and oil cakes would be cost effective when these ingredients are available at a cheaper rate than mineral mixtures. The best ingredients are available at a cheaper rate than mineral mixtures. The best source to provide various minerals depends on the feed ingredients fed to the animals, the availability of leguminous green fodder and the type of animal.

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