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Mineral in crop residues and interaction with soil minerals contents in Ethiopia: review

Abstract

This review aims is to explore different authors views about mineral contents of crop residues, aiming to demonstrate the benefit of supplementing minerals from soil with crop residue minerals, as well as point out effects on livestock productivity. Crop residue is the second main livestock feed resource, followed by natural pasture in Ethiopia, which has poor nutritive values. Nutrient composition of plant materials/crop residue depends on the nutrient availability of the soil, while nutrient availability of the soils depends on the nature of soils, season, climate, the topography of the land, interaction between animals and humans, time/period of sampling and application of inorganic fertilizers. Trace minerals deficiency of grazing land causes different effects on livestock and the plants themselves. Many incidences of mineral inadequacies in forages and soils have turned out the main causes of reproduction failure and low production rates by Ethiopian livestock.

Keywords: mineral, crop residues, soil mineral, interaction, protein

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Introduction

In Ethiopia, crop residue is the second main livestock feed resources followed by natural pasture.[1] Different authors were investigate different experiments on crop residue at different time to evaluate its impact on livestock productivity.[1–7] This crop residue has contains different nutrients but low in protein content. Most of the researchers were concerned about its macronutrient content rather than micronutrient content. Only a few researchers were tried to investigate the micronutrient content of crop residue but limited only on calcium and phosphorus.

Plants are the feed sources of animals but the nutrientscontent of the plant is depending on the nutrient availability in the soil that determines the productivity of animals. Also besides, soil formation is depending on the geologic and climate condition of the areas.[8] According to FAO (1998),[9] there are 19 general clusters of similar soil types and identified soil map descriptionsina different part of the country. Types of soil and environmental conditions are affecting the presence of sufficient amounts of minerals in the soils and plant uptake. For example, uptake of Ca, Mg and Mo can be limited in acidic soils. These causes for the inadequate presence of minerals in forage and plant materials. This indicated thatit is the principal cause of livestock reproduction failure and low production rate.[10–12] Therefore, this review aims are to explore different views of authors about crop residue minerals content and to show the interaction of soil mineral contents and its effects on livestock productivity.

Minerals availability in the soils

According to Helias A, *et al*. (2012)[13] report a research investigation on soil minerals deficiencies has been starting from the 1920s while more intensified after the Second World War. The analysis of soil chemistry grew and modernized from time to time with cost-effective. In early periods, only determine the total levels of micronutrients in the soil yet now determine the actual level of micronutrients in the soil and plant materials by using least-cost methods like infrared radiation measurements by taking a sample. About 42% of Ethiopian highland agricultural areas, Vertisols, Nitosols, Acrisols, and Cambisols are the most common from more than 17 soil types.[14] According to his description, Nitosols and Acrisols are not suitable for agriculture due to its acidity, low nutrient content, and readability. Different minerals are existingin the soil in different concentration amounts and states. Organic matter is closely associated with the nutrient status of soil because it contributes to the soil cation exchange capacity (CEC).[15] It is also an important source of inorganic nutrients for production in natural ecosystems.[16] Most of the Ethiopian highland areas are rich in potassium and CEC with international standard but the availability of nitrogen, phosphorus, and organic content is very low that causes low crop yield.[9] Ethiopian wheat cultivar grew sample soils are deficient in copper, zinc, molybdenum, boron, and iron.[9,17,18] In recent years, researchers indicated that the main causes of Ethiopian crop yield losses are depletion of macro and micronutrients in the soil.[9] There are sufficient amounts of K, Ca, Mg, Fe, Cu, B, and Mo in the soils butdue to the acidity of the soil, the plant couldn't uptake enough amount of Ca, Mg, and Mo from the soil.

Soil and forage mineral concentration is affected by sampling periods and seasons.[19] For example, soil Cu, Fe, Mn, Zn, and Se and all forage minerals except Se were affected by sampling periods and season, respectively. All soil minerals level except Co and Se were found above the critical levels in all seasons and adequate for normal growth of plants but Cu and Mn were lower during winter.[19] In addition to carbon, hydrogen, and oxygen, most important macro minerals (N, P, and K), secondary macro minerals (Ca, Mg, and S) and micro minerals (B, Cl, Cu, Fe, Mn, Mo, and Zn) are indispensable for the health and growth of plants. Due to the deficient of these one or more minerals, the optimum yield of the crop will fail and the quality of foods will be inadequate. To afford adequate and quality food for the population, micronutrient deficiencies in agricultural and horticultural crops should be acknowledged and treated.[9]

Crop residues mineral composition

In our world, around 3.8 billion tones of crop residues are produced annually.[20] It contains different amounts and types of nutrients, basically, Nitrogen (3 to 8.2 kg /tones DM), Phosphorus (0.2 to 0.6 kg/tones DM) and Potassium (7.2 to 23.3 kg/tones DM).[21] Crop residues are the most available and low-cost animal feed resources in the majority of developing countries.[3] According to Adugna(2012),[1] it is the second major livestock feed resource in Ethiopia followed by natural pastures.Crop residues have low nutritional contents (protein and energy), poor digestibility and intake and high fiber content, which is un-degradable by the host enzymes.[1–7] However, the mineral contents of crop residues are not well described. Researchers have examined several crop residues and agro-industrial by-products, available in Ethiopia as a potential for ruminant feeds concerning to their prospective supply of crucial dietary minerals.[22] Due to the inadequate supply of Na, P, Cu, Mo, I, Se, and Zn and crop residues based animal rationhas significantly affected livestock reproductivityand production performances. By different research investigations, 21 essential minerals are identified for crops, livestock, and humans as present in Table 1.

Table 1 Essential macro and micro minerals for crop, livestock and humans (+ = essential; _ = nonessential; ±= necessity not demonstrated, but assumed to be beneficial)

Nutrients/minerals	Crop	Livestock/ humans	Nutrients/minerals	Crop	Livestock/ humans
Potassium	+	+	Iron	+	+
Sodium	±	+	Zink	+	+
Phosphorus	+	+	Copper	+	+
Calcium	+	+	Cobalt	±	+
Sulfur	+	+	Molybdenum	+	+
Magnesium	+	+	Selenium	±	+
Chlorine	±	+	Nickel	±	+
Nitrogen	+	+	Silicon	±	+
Boron	+	_	Manganese	+	+
Iodine	_	+	Chrome	_	+

Sources; Marschner, 1995;[21] Garrow, *et al*., 2000; Wiseman, 2002; Nubé and Voortman, 2006

According to Khalili (1993),[23] the analysis of feed samples showed that all feed types are deficient in Na. Hay, pasture grass, barley straw, grains, and teff straw were also low in P, Mg, Cu, and Zn but in all feeds, Fe content was found extremely high and Mn levels were also higher than the dietary requirements as present on (Table 2 & 3).

Table 2 Average macro and micro minerals in feed samples mg/kg on dry matter basis[23]

Feeds	Ca	K	Mg	Na	P	Cu	Fe	Mn	Zn
Hay	5500	16700	2800	300	2100	7	610	313	25
Pasture	6300	21700	2200	100	3400	9	1347	266	36
Barley straw	3100	13300	1100	400	1400	10	377	59	18
Teff straw	3800	9200	1500	200	1100	7	211	209	30
Grains	900	5800	1300	100	3700	7	473	65	31

Table 3 Different crop residues minerals composition in West Africa at dry season[5]

Feed	Cp (%)	P (%)	Ca (%)	K (%)	Fe (ppm)	Reference
Cowpea	13.63-17.8	0.132-0.28	1.05-1.425	1.56	225.94	
Sorghum	3.24-5.56	0.07 -0.168	0.32- 0.38	0.83	161.06	Ajeigbe, 2003; Mosimanyana and Kiflewahid, 2006
Maize	2.69-7.84	0.03-0.123	0.24-0.278	1.14	271.47	
Millet	5.52-6.2	0.043-0.22	0.309	-	-	
Groundnut	14.8 - 21.6	-	-	-	-	Omokanyeet *al*., 2001
Wheat bran	11.48-16	0.31-1.2	0.381	-	-	Mosimanyana and Kiflewahid, 2006

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Table 4 Mean mineral concentrations zebu blood serum (mg/l) in different seasons

Component	Ca	Cu	Fe	K	Mg	Mn	P	Zn
Dry season	153	0.66	1.36	139	17	0.26	141	0.91
Wet season	337	1.38	3.27	249	23.5	0.11	141	1.45
Critical level	80-120	0.8-1.2	1.1-2.2	180-220	18-30	0.03	40-65	0.8-1.2

Source; Grace, 1983;[30] Gizachew, *et al.,* 2002

According to Khalili*et al.* (1993),[23] low mean level of Cu (0.62 mg/l) and Zn (0.66 mg/l) as compared to the critical levels published by McDowell (1985)[10]: 0.65 mg/l for Cu and 0.60 to 0.80 mg/l for Zn in the blood plasma samples. Based on his study, the level of Ca, P, Mg and K, and all trace elements was significantly affected by season's variation. Besides, most of the animals have low plasma Cu and Zn during the rainy season.

Factors affecting minerals composition in crop residues

The mineral composition of crop residues is depending on soil types, climate condition and season. For example; Ca concentration dropped by 55% (from 337 mg/l in the wet season to 153 mg/l in the dry season. The concentration of K, Mg, and Cu are below the critical level during the dry season, but above during the wet season. Chemical fertilizer application also other factors affecting the mineral concentration of crop.[16]

Mineral deficiency effects on animals and plants

Trace minerals deficiency on grazing land causes different effects on livestock and the plant itself. Low digestibility, low crude protein content and low content of available minerals and vitamins in the cereal residues cause weight gain loss in different livestock species.[24] Many incidences of minerals inadequacies in forages andsoils have been reported principal causes for livestock reproduction failure and lowproduction rate.[10–12]

According to Kaat Neckermann (2017),[25] the poor quantity and quality of feed resources and its mineral deficiencies are the main causes of zebu cattle milk production reduction in Ethiopia. He has analyzed the concentration of the minerals in feed and serum for dairy cattle. The content of B, Ca, Cu, Fe, K, Mg, Mn, Na, P,Zn,and Mo are deficient in the feed. Both excessive and underprovided amounts of minerals in the ration are cause for toxicity and deficiency, respectively.[26] Most minerals have more than one task, which makes it difficult to establish a criterion for adequacy and dietary mineral levels either sufficient for one body function or insufficient for another. Generally, minerals play a role as catalytic (enzyme function), physiological (maintaining osmotic pressure), structural (bone strength), and regulatory processes (cell replication and differentiation).[27,28]

The following Figures 1, 2 &3 are shown that the relationship between mineral supply and animal production. It shows also marginal bands between adequate and inadequate or toxic dietary concentrations. The graph and marginal ranges move to the right as absorbability of the mineral source declines; thus "A" represents the more and "B" (dashed line) the lesser absorbable of two mineral sources.[29–32] 'Requirements' are variously set within the central adequate band from minimum requirements to safe allowances, depending on the extent to which absorbability and other variables are taken into consideration.

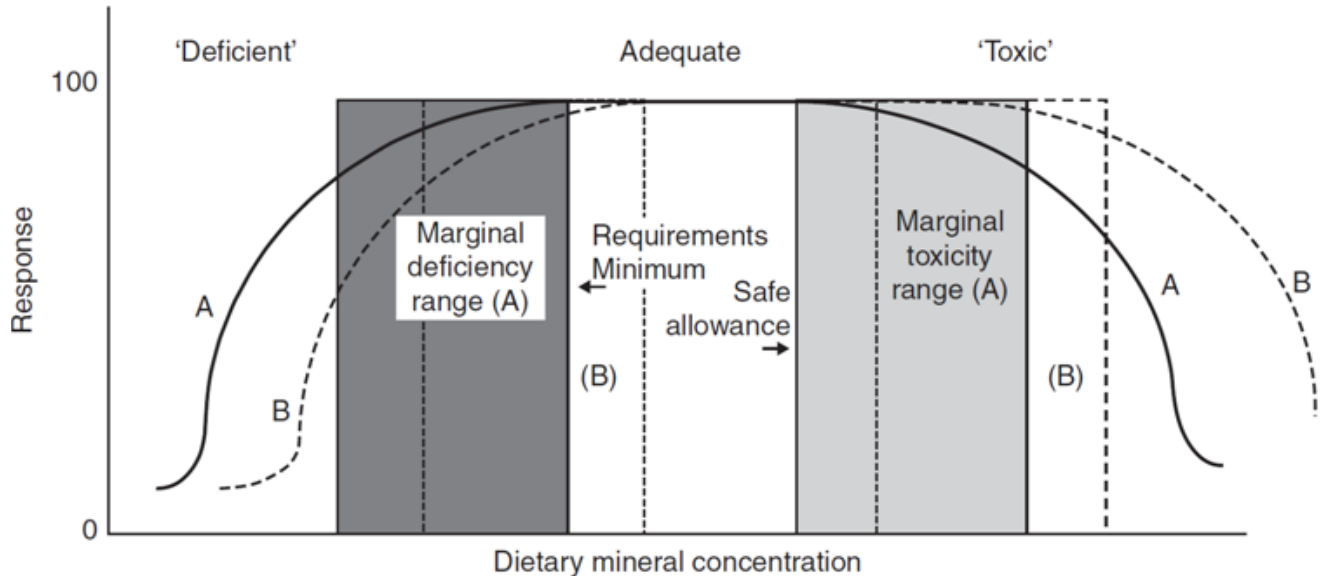

Figure 1 Dose-response curve for feeds A and B and A has a higher mineral absorption coefficient than B, (Suttle, 2010).

Figure 2 Trace minerals deficiencies on ruminant animal's causes for body condition loss.

Figure 3 Trace minerals deficiencies on plants.

Conclusion

Different experiments were conducted in our country to quantify mineral availability in the soil, plants, and body of animals including its effect on those organisms. However, there is limited research on crop residue mineral content and its impact on livestock productivity improvement. Therefore, due to havingthe significant effect of minerals on livestock productivity should be analyzing the mineral contests of the crop residue at a time before feeding for our animals.[33–38]

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Conflicts of interest

The authors declare that there was no conflict of interest.

References

1. Adugna Tolera. Potential for Development of Alternative Feed Resources in Ethiopia. An Assessment Report prepared for ACDI/VOCA. Addis Ababa Ethiopia: 2012; p. 20.
2. Preston TR, Leng RA. Matching Livestock Systems with Available Resources. *IlCA.* 1986.
3. Smith OB. Feed resource for intensive smallholder systems in the tropics: the role of crop residues. In Proceedings of the XVII International Grassland Congress, 18–21 Feb; 1993. Rockhampton: Australia; 1993.
4. Tesfaye Alemu A, Musimba NKR. Study on the Chemical Composition, Intake and Digestibility of Maize Stover, Tef Straw and Haricot Bean Haulms in Adami Tulu District, Ethiopia. *Kasetsart J. (Nat. Sci.)*. 2003;37:401–407.
5. Singh BB, Musa A, Ajeigbe HA, et al. Effect of feeding crop residues of different cereals and legumes on weight gain of Yankassa rams. *International Journal of Livestock Production*. 2011;2(2):17–23.
6. Daniel Taddess, Mengistu Urge, Gebeyehu Goshu, et al. Evaluation of Chemical Composition and in vitro dry Matter Digestibility of Sorghum Stover Ensiled with Urea and Effective Microorganisms (EM) in West Hararghe Zone, Eastern Ethiopia. *American–Eurasian J. Agric. & Environ. Sci*. 2016;6(8):1473–1483
7. Lemma Gulilat, Endalew Walelign. Evaluation of milk production performance of lactating Fogera cows fed with urea and effective micro–organisms treated rice straw as basal diet. *International Journal of Scientific and Research Publications*. 2017;7(6):2250–3153.
8. Jones Jb. Plant Nutrition and soil fertility manual. CRC Press; 2012.
9. Food and Agriculture Organization. Soil Country Profiles: Ethiopia; 1998.
10. McDowell LR. Nutrition of Grazing Ruminants in Warm Climates. Academic Press: New York; 1985; p. 443.
11. Mc Dowell LR, Conrad JH, Hembry FG. Mineral for Grazing Ruminants in Tropical Regions. Univ. of Florida: Gainesville; 1993.
12. Mcdowell LR, Conrad JH, Ellis G, et al. Minerals for Grazing Ruminants in Tropical Regions. *US agency of international development*. 1977.
13. Helias A, Roelf L, Voortman, et al. Scarcity of micronutrients in soil, feed, food, and mineral reserves urgency and policy options. Platform for Agriculture, Innovation & Society. 2012.
14. Engida Mersha. A desertification convention–based classification of moisture zones of Ethiopia. *Ethiopian Institute of Agricultural Research*. 2000;2(1):1–9.
15. Magdoff F, Bartlett RJ. Soil pH buffering revisited. *Soil Sci. Soc. Am. J*. 1985;62:145–148.
16. Fritzsche FD, Solomon J, Lehmann M, et al. Soil organic matter dynamics in the sub–humid agroecosystems of the Ethiopian highlands. *Soil Science Society of American Journal.* 2002;66:969–978.
17. Baissa T, Suwanarit A, Osotsapar Y, et al. The status of Mn, Fe, Cu, Zn, and B in Rift Valley soils of Ethiopia: Laboratory Assessment. *Kasetsart J. (Nat. Sci.)*. 2007;41:84–95.
18. Hailu H, Mamo T, Keskinen R, et al. Soil fertility status and wheat nutrient content in Vertisol cropping system of central highlands of Ethiopia. *Agriculture and food security.* 2015;4(9):1–10.
19. Zafar Iqbal K, Altaf Hussain M, Ashraf, et al. Evaluation of Variation In Soil and Forage Micro–Mineral Concentrations in a Semiarid Region of Pakistan. *Pak. J. Bot*. 2005;37(4):921–931.
20. Lal R. World crop residues production and implications of its use as a biofuel. *Environ Int*. 2005;31:575–584.
21. Marschner P, Rengel Z, et al. Nutrient cycling in terrestrial ecosystems. Spring–Verlag Berlin Heidelberg; 2007. pp. 183–214.

22. Kabaija E, Little DA. Potential of agricultural by–products as sources of mineral nutrients in ruminant diets. *International Livestock Research Institute*. 1998.

23. Khalili M, Lindgren E, Varvikko T. A survey of mineral status of soil, feeds and cattle in the Selale Ethiopian highlands. I. Macroelements. *Tropical Animal Health and Production*. 1993;25(4):162–172.

24. Owen E. Cereal crop residues as feed for goats and sheep. *Livestock Res. Rural Deve*. 1994;6(1).

25. Kaat Neckermann. Mineral Status of Zebu Cattle (Bos Indicus) in the Ethiopian Rift Valley. 2017.

26. National Research Council. Nutrient Requirements of Dairy Cattle. 7th edition. National Academies Press; 2001.

27. Suttle NF. Mineral Nutrition of Livestock, 4th edition. London: CAB International. 2010.

28. McDonald P, Edwards RA, Greenhalgh JFD, et al. Animal Nutrition, 7th edition. Pearson Education Limited. 2011.

29. Ajeigbe HA, Oseni TO, Singh BB. Effect of planting pattern, crop variety, and insecticide on the productivity of cowpea–cereal systems in Northern Guinea Savanna of Nigeria. *Journal of Food, Agriculture and Environment*. 2006;4:101–107.

30. Gizachew L, Hirpha A, Jalata F, et al. Mineral element status of soils, native pastures and cattle blood serum in the mid–altitude of western Ethiopia. *African Journal of Range & Forage Science*. 2002;19(3):147–155.

31. Helias A, Roelf L, Voortman, et al. Scarcity of micronutrients in soil, feed, food, and mineral reserves urgency and policy options. Platform for Agriculture, Innovation & Society. 2012.

32. Menale Kassie. Land and soil resources account of Ethiopia. 2016.

33. Mosimanyana B, Kiflewahid B. Feeding of crop residues to milking cows in small scale farms in Botswana. 1987.

34. Omokanye AT, Onifade OS, Olorunju PE. The evaluation of dual–purpose groundnut (Arachis hypogaea) varieties for fodder and seed production at Shika, Nigeria. *J. Agri*. 2001;136(1):75–79.

35. Puls R. Mineral Levels in Animal Health–Diagnostic Data. *Can Vet J*. 1989;30(2):190.

36. Underwood EJ. The Mineral Nutrition of Livestock, 2nd edition. 1981.

37. Vargas E, Mc Dowell LR. Mineral Deficiencies of Cattle in Central America and the Carbean, Emphasizing Cost Rica. *Proc. Int. Conf. Liv. Trop*. 1997.

38. Logah V. Chemical Properties of Maize Residues under Application of Organic and Inorganic Nutrient Sources. *International Journal of Environmental Science and Development.* 2011;2(5).

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