1. Forages and precision mineral feeding: results from the USA

The standard variability in energy, protein, or macro minerals values in forages is relatively small compared to trace minerals (TM) one. Forages also contain antagonists (for example Cu, S, Mo and Fe) that reduce the bioavailability of some minerals making it more difficult to provide/predict a precise supplementation.

by Dr Rahma Balegi, Animine R&D, and vet. Leandro Royo, Animine product manager, Animine. www.animine.eu

Having an accurate data of the TM level in the forages is extremely important. These data allow nutritionists to take good decisions about supplementation programmes.

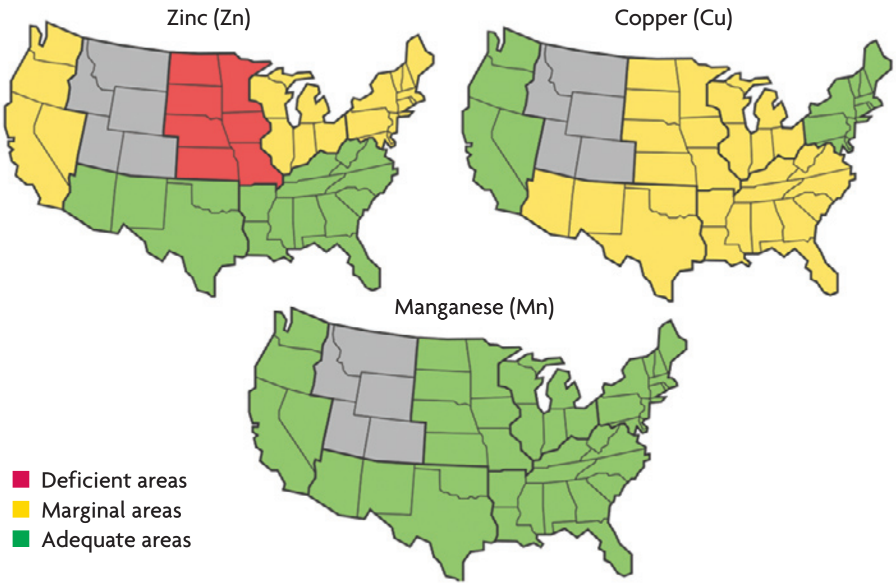

Fig. 1. Regions of the US classify according to Mortimer et al. (1999).

A net global tendency to over-supplement TM

Nowadays the over-supplementation is a common practice in farms all over the world. This situation can cause toxicity of some TM (for example Cu, Se, etc.), but the most important consequence induced is the high cost of these over-supplementations.

Another side effect is the large environmental impact caused by the withdrawal of non-renewable resources from mines but also by the challenging management of effluents from farms containing high amount of supplemented minerals, excreted by animals. This means that extra-money invested in over-supplementation is wasted and polluting the environment.

On another side, cases of deficiencies are less and less frequent, and not easy to detect. They can induce a reduction in performance and/or reproduction, or in extreme cases some pathologies like mastitis and lameness. Cases of severe symptoms of deficiencies or even deaths are rare nowadays.

Knowing quickly and accurately the minerals content of forages in the basal diet has become a very important aspect of making livestock farming more profitable and more environmentally friendly. As one of the main factors that affect mineral content in forage is the soil, it is important to know what you can expect in your geographical area.

Cu, Zn and Mn content in forages (US example): Animine review

A database of forages mineral content was established by Animine from 12 scientific publications with a particular focus on Cu, Mn and Zn. In total, there were 20,292 forages samples collected from 1982-2008 from six different regions in the USA (Far West, Great Lakes, Great Plains, Northeast, Southeast and Southwest).

There were no data for Mn from the Far West and the Great Lakes.

The forages were mainly grass, grass silage and corn silage.

Forages from the Northeast region had the highest Cu content, with an average value of 12.8ppm, followed by the Far West region with an average value of 10ppm (Table 1). Southeast region showed the lowest concentration of Cu in forages. The Southeast region had the highest concentration in Mn with an average value of 86.5ppm and a maximum observed level of 201ppm.

Northeast region presented the lowest concentration of Mn in forages. Zinc was high in the Southeast and Southwest areas with respectively an average of 30.4 and 30.8ppm. A maximum concentration of 38.3ppm of Zn was recorded in the Southwest region.

Get to know your geographical mineral profile and adjust your supplementations

The regions were classified according to the content of their forages in Cu, Mn and Zn as deficient, marginal or adequate following the classification of Mortimer et al. (1999); Fig. 1.

As shown in Table 2, all the areas were marginal in Cu except for the Far West and the Northeast regions which were adequate. Manganese, was adequate in all the studied areas as all the regions were above 40ppm.

Finally, Zn was deficient in the region of Great Plains, adequate in the Southeast and Southwest and marginal in the other regions of the USA.

Region	Number of samples	Cu (ppm) ± SD	Mn (ppm) ± SD	Zn (ppm) ± SD	References
Far West	84	10.0±3.2	–	28.0±2.4	Arthington 2002 Barnes et al 1990 Berger 1996 Chelliah et al 2008 Corah and Dargatz 1996 Davis et al 2002 Espinosa et al 1991 Galdámez-Cabrera at al 2004 Greene et al 1998 Kappel et al 1982 Kicaid and Cronrath 1982 Li et al 2005
Great Lakes	89	5.9±1.6	–	24.7±2.1	
Great Plains	243	6.7±1.2	78.5±33.4	17.8±3.4	
North East	9,777	12.8±0.50	56.2±14.2	25.0±4.7	
South East	1,416	5.3±2.5	86.5±39.0	30.4±15.5	
South West	8,683	5.5±1.3	65.9±28.4	30.8±1.5	

Table 1. Concentration and variability of forage classify by areas in the US.

It is nevertheless important to keep in mind that the values presented in the table are references for forages and do not reflect the animal requirements.

For example, NASEM (2021) recommendations for Zn are around 60ppm for lactating dairy cows. Due to some antagonistic interrelationship among certain TM, it is quite difficult to classify the forages only regarding its TM element content. For example, it is well known that dietary copper requirements are affected by S, Mo and Fe which decrease its bioavailability.

This classification can be a guide to understand if an area is mineral deficient or not. However, it is not a substitute for accurate mineral analysis of forages, as there are other factors beyond the soil that can affect the mineral content of forages used in the total mixed rations (TMR) for dairy cows.

Main factors for TM variability in forages

Globally, the concentration of TM in forages can be affected by several factors. For example, the crop is a major factor of variation. In fact, the genus and species of the crop have an important effect as well as the stage of maturity and the structure of the plant (leaf to steam ratio).

In addition, the soil type and pH, the type of fertilisation, and the season can considerably affect the TM concentration in forages. These latest factors can be summarised by geographical areas. Another important source of variability is the method of analysis and the representativeness of the samples. In fact, the type of methodology used (ICP-OES, ICP-MS, etc.) to analyse the TM content and the analytical variations among laboratories can lead to completely different values.

Furthermore, accurate sampling is essential to obtain reliable TM values. Most people underestimate the number of individual samples that should be taken to get a good representative sample.

Caution needs also to be exercised so that the samples are not contaminated during the grinding process (for example, iron as one of the major antagonists of copper).

New handheld technology for analysing TM

Because of the current high cost of wet chemistry analytical methods used in laboratories, TM content are not analysed in routine. In order to perform more accurately mineral supplementation in a accessible and immediate way at the farm, Animine developed AniGun, a handheld analytical instrument for assessing TM content in forages.

It uses the XRF (X-ray fluorescence spectrometry) technology, adapted from other industries to the animal feeding objective. This handheld device can evaluate both macro and micro minerals in forages rapidly and in an affordable way. When NIR is only adapted to organic fraction, XRF is essential to obtain inorganic fractions.

Consequently, XRF is a complementary option to the NIR portable device. AniGun will help nutritionists to evaluate mineral content in the basal diet and, therefore, to achieve a precise TM intake.

Precision minerals feeding: analysing and adjusting TM

In summary, trace minerals are highly variable nutrients found in the most variable feedstuff: forages. Geographical areas and local practices are a significant source of variation in TM concentrations in commonly used forages.

Using new technologies like AniGun for local analysis is recommended to establish reference levels for farmers who crop most of their forages.

It is also necessary to know the concentration of antagonists to readjust the supplementation especially for copper. Feeding a TMR properly enriched with highly bioavailable trace elements is the best approach to reach an optimal level of production, reducing the impact on the environment. ■

References are available from the author on request

Table 2. Criteria of classification of deficient, marginal and adequate areas in the US.

Trace minerals	Deficient (ppm)	Marginal (ppm)	Adequate (ppm)
Copper	‹4	4-10	≥10
Manganese	‹20	20-40	≥40
Zinc	‹20	20-30	≥30