Strengthening Capacity in Environmental Physics, Hydrogeology and Statistics for Conservation Agriculture Research

CEPHaS Project Briefing

No. 14 September 2021

THE POTENTIAL IMPACT OF CA ON THE MICRONUTRIENT CONTENT OF FOOD

What are micronutrients?

Much progress has been achieved globally to ensure that people have sufficient nutrients in their diet such as proteins and carbohydrates, but micronutrients, including vitamins and trace elements are also important and micronutrient deficiencies (MND) or hidden hunger is a serious challenge, estimated to affect over two billion people globally. Micronutrient deficiencies are the primary cause of many diseases, and exacerbate others. They also contribute to poor physical and mental development in children, mental retardation, blindness and general losses in productivity and potential.

Selenium (Se), Iodine (I) and Zinc (Zn) are some of the important mineral micronutrients which are often deficient in diets. Globally, it is estimated that 1 billion people are affected by insufficient dietary selenium and 750 million people suffer from I deficiency. The prevalence of Zn deficiency is higher, varying between 15 and 50 percent of the populations of countries in sub-Saharan Africa and South Asia.

Figure 1 *Organic matter build-up due to minimum soil tillage and residual retention.*

Micronutrients in soil and crops

Soil is the reservoir and the main source of mineral micronutrients, and the uptake of mineral micronutrients from soils to crops is the main entry point into the food system. The concentration of micronutrients in the food crop depends on, among other factors, their concentration in the soil, but also on soil properties such as pH, organic carbon content and the concentration of hydrous oxides of iron (Fe), Aluminium (Al) and Manganese (Mn) which affect mobility of MN. For example, it is recognized that micronutrient species, such as selenite ions ($HSeO_3^-$, SeO_3^{2-}) are adsorbed strongly on hydrous oxides at low pH (3.5–6.5). *Hence soil management practices to increase the soil pH enhances the bioavailability of micronutrients*[1]. Increased organic carbon content similarly increases micronutrient bioavailablity. Soil management practices which enhance micronutrient availability include climate smart agriculture practices of agroforestry, manure application and conservation agriculture.

On the other hand, soil management practices that are characterized by intensive cropping, resulting in large scale removal of biomass from the soil, as well as widespread use of fertilizers, can deplete the soil of its native micronutrient content.

Figure 2 *Maize legume associates (cowpea intercropping) in conservation agriculture cropping system.*

1 Ligowe, I S, Nalivata, P C, Njoloma, J, Makumba, W, and Thierfelder, C. (2017). Medium-term effects of conservation agriculture on soil quality. African Journal of Agricultural Research, 12(29), 2412–2420.

Conservation agriculture and soil micronutrient concentration

Conservation Agriculture (CA) is a sustainable approach to agricultural production, which aims to protect soil from erosion and degradation, improve its quality and biodiversity (Figure 1) and contribute to the preservation of natural resources, water and air, whilst optimising yields. Conservation agriculture has three core principles: minimum soil tillage, permanent soil cover and crop diversification by rotation or intercropping (Figure 2). Benefits of CA include improved infiltration of water, reduced surface soil temperatures and reduced erosion, along with a general improvement of soil health and biodiversity. There is evidence that this improvement of soil health also results in better bioavailability and supply of micronutrients, such as available soil Se, for uptake by the crop. This has been demonstrated in the Chitedze experiment in Malawi (Figure 3).

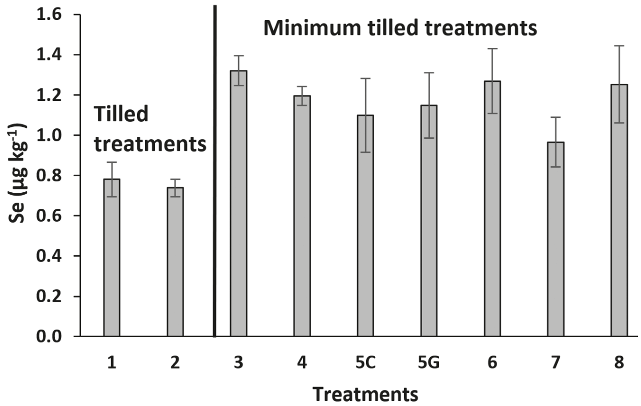

Figure 3 *Concentration of soluble soil selenium (µg/kg) from the tilled and minimum tilled treatments in the 9th year of long term conservation agriculture trial at Chitedze Research Station — Malawi. Numbers represent a range of cropping treatments.*

Micronutrient (Se) biofortification in conservation agriculture

Agronomic biofortification involves the application of micronutrients in fertilizer to increase their concentration in the crop. *Experiments at Chitedze showed application of 20 g ha-1 Se*[2] produced sufficient grain Se enrichment in maize and legumes in conservation agriculture plots to provide the recommended dietary Se requirement. Improved soil fertility in the CA plot resulted better recovery of applied Se than in the conventional maize cultivation treatment.

Studies on the bioaccessibility of applied Se[3], using stable isotopes, showed that, in CA plots, it accumulated in highly bioaccessible Se organic compounds in all the three crops (Maize, cowpea and groundnuts) of dietary importance in Malawi. Biofortified Se in CA cultivated crops contributed 88–97% of the total Se in the edible portions, with more than 90% of it in an organic form. Selenomethionine was the main form of the isotopically fertilizer Se in the grain, with an abundance of 92% in maize, 64% in cowpea and 85% in groundnut.

Conclusion

Practicing conservation agriculture cropping system under long term could be a way of alleviating micro-nutrient deficiencies in Sub-Saharan countries and other areas with high risks of MND. The improved soil fertility, due to soil organic matter build up in CA, with optimum nutrient mineralization facilitates the availability of microutrients in available form for plant uptake. The increased crop yield under conservation agriculture due to improved soil health, optimizes the recovery of the applied fertilizer micronutrients/ Se. Fertilizer Se applied to crops grown on CA plots, leads to the accumulation of highly bioaccessible Se organic compounds in dietary crops and could have a positive contribution to human health and alleviation the severity of MNDs.

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Researching Soils, Crops and Water in Zambia

WHO ARE WE?

We are soil scientists, agronomists, hydrogeologists, geo-physicists, statisticians and agricultural economists from the University of Zimbabwe, the University of Zambia, Lilongwe University of Agriculture and Natural Resources, the University of Nottingham, Rothamsted Research, Liverpool School of Tropical Medicine and the British Geological Survey. We are working with the Kasisi Agricultural Training Centre, Zambian Agriculture Research Institute, the Department for Agricultural Research Services (Malawi), and our commercial partner, Delta-T Devices (UK).

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2 Ligowe, I S, Young, S D, Ander, E L, Kabambe, V, Chilimba, A D C, Bailey, E H, Lark, R M, Nalivata, P C. Selenium biofortification of crops on a Malawi Alfisol under conservation agriculture, Geoderma, Volume 369, 2020, 114315.

3 Molly Muleya, Scott D, Young, Saul Vazquez Reina, Ivy, S, Ligowe, Martin, R, Broadley, Edward, J M, Joy, Prosper Chopera, Elizabeth, H, Bailey. Selenium speciation and bioaccessibility in Se-fertilised crops of dietary importance in Malawi, Journal of Food Composition and Analysis, Volume 98, 2021, 103841.

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