Research Application Summary

# Soil micronutrient supply and grain quality for human nutrition in selected parts of Morogoro, Tanzania

Imakumbili, M.L.E.[1], Semu, E.[1] & Semoka, J.M.R.[1]
[1]Sokoine University of Agriculture, P. O. Box 3007, Morogoro, Tanzania
Corresponding author: imakumbili@hotmail.com

**Abstract**

Soils worldwide have become depleted of micronutrients. This has resulted in an increase in micronutrient deficiency diseases for people consuming micronutrient poor foods as a sole source of nutrition. This study was carried out to determine whether low-input farming is producing micronutrient deficient foods in selected areas of Morogoro region of Tanzania. It was found that some of the soils were not deficient in zinc, iron and copper. Maize grain was deficient in human dietary zinc and iron when compared against set targeted levels. Maize grain zinc ranged from (7.11-43.60)µg/g while the iron ranged from (16.55-39.96) µg/g.

Key words: Micronutrients, nutritional deficiency, soils, Tanzania

**Résumé**

Les sols dans le monde entier sont de plus en plus épuisés des micronutriments. Ceci a eu comme conséquence une augmentation des maladies d'insuffisance en micronutriments pour les populations consommant des nourritures pauvres en micronutriments comme source unique de nutrition. Cette étude a été effectuée pour déterminer si l'agriculture de faible demande produit les nourritures déficientes en micronutriments dans des régions choisies de Morogoro en Tanzanie. On a constaté que certains sols n'avaient pas une carence en zinc, fer et cuivre. Le grain de maïs avait une carence en zinc et fer diététiques humains une fois comparé aux niveaux d'ensemble visés. Le zinc de grain de maïs s'est étendu (de 7.11 à 43.60) µg/g tandis que le fer s'étendait (de 16.55 à 39.96) µg/g.

Mots clés: Micronutriments, insuffisance alimentaire, sols, Tanzanie

## Background

Due to the increased prevalence of micronutrient deficiency diseases, there is now a growing concern on the quality of food being consumed. As most nutrients come from soil agriculture, soil may be a contributor to micronutrient deficient foods that are causing micronutrient malnutrition in populations consuming them. Iron and zinc deficiency are major problems today.

Subsistance farming communities are most vulnerable to micronutrient deficiency diseases especially since these people have limited access to outside food sources to supplement the low nutrient foods that they produce and live on.

Nutrient depleted soils are a major cause of low crop productivity. However, hardly any studies have been carried out to assess the contribution of low input farming to micronutrient deficient foods and in turn diseases. This information would be particularly helpful in Africa where more than 70% of the farmers are low input producers with limited access to fertilisers and organic materials that could be added to replenish the lost nutrients.

This study was carried out to assess whether the foods produced by low input farmers in some areas of Morogoro region in Tanzania have low human dietary zinc and iron. The soil micronutrient status was also checked to see if the food crops were being grown on depleted soils. An experiment involving soil micronutrient fertilisation was also carried out on these soils just to observe the extent to which the micronutrient content of seed would increase if this was done.

## Literature Summary

It is difficult for humans today to acquire all the minerals needed from food as soils have become deficient (Down to Earth, 2010). Africa's soils are especially deficient in key micronutrients. One study showed that Sub-Saharan Africa countries like Tanzania, Malawi, Kenya, Burundi and Rwanda had experienced very high nutrient depletions (Roy *et al.,* 2003). Continuous farming without replenishing soil nutrients has depleted three-quarters of farmland in the continent (AGRA, 2010). Unless farmers replenish nutrients, the mineral content of harvested food will continue to decrease (Marler and Wallin, 2006). Without access to fertilizers and organic matter in adequate amounts, farmers' yields are also declining (AGRA, 2010). Where fertilizers are added, this is largely NPK. Micronutrient fertilisers are often never used at all (Mtambanengwe *et al.,* 2007).

According to PureNewYouSoil.com (2010), "…minerals are an essential part of our natural diet and a lack of them may in part account for our increasing susceptibility to diseases - such as heart disease (magnesium), cancer (selenium), diabetes (chromium), anaemia (iron and, to some extent, copper) and mental illnesses (zinc)."

## Study Description

The study was carried out in Morogoro region of Tanzania. The area lies between latitude $5^{o}$ 58" and $10^{o}$ 0" to the South of the Equator and longitude 35$^o$ 25" and 35$^o$ 30" to the East. The areas selected for the study included Mzinga, Mikese, Mlali, Mkuyuni, Ruvuma Village and Sokoine University of Agriculture. The research was carried out in two phases.

**Field survey.** Background information on the farming history of each field was collected. It was important to know whether a farmer used fertilisers or not and also to know the length of time for which the land had been used for farming. Soil samples were collected randomly from at least three farms in each area. Soil samples were collected at a depth of (0-20) cm. These were then analysed for the micronutrients zinc, iron and copper. A general routine analysis was also done to get information on the soils fertility status. Maize (*Zea mays* L.) grain from the sampled farms was later collected and analysed for zinc, iron and copper. Maize was chosen as the indicator crop because it is an important staple food in Tanzania. It would, thus, give a good reflection on the micronutrients consumed by the communities in the region. The zinc and iron concentrations in the sampled maize grain were then compared with set target levels of iron and zinc by using the t-test. Correlations between the soil content of these micronutrients and their concentration in maize grain were also done.

**The sreenhouse experiment.** Two soils, one without deficiencies and another which showed some deficiencies in one or more of the analysed micronutrients were selected for the greenhouse experiment. Beans (*Phaseolus vulgaris*, L.) were grown since seeds could be obtained within 2 - 3 months. Beans are also a staple food in the region and are being bred for zinc and iron seed enrichment. Three plants were grown in each pot but they were later thinned to two at flowering. The removed plant was used for biomass determination. The beans were subjected to eight different fertiliser treatments. The treatments comprised of a control (no fertiliser added); NPK-fertiliser (only); NPK + 7.5 mg Zn /kg ; NPK + 15 mg Zn /kg; NPK + 15 mg Zn /kg + Fe 7.5 mg/kg; NPK + 15 mg Zn /kg + Fe 15 mg/kg; NPK + 15 mg Zn /kg + 15 mg Fe /kg + 5 mg Cu/kg and NPK + 15 mg Zn /kg + 15 mg Fe /kg + 10 mg Cu/kg. The pots were arranged in a randomised complete block design with three replicates. The bean seeds harvested were analysed for the micronutrients zinc, iron and copper. The seed weight per plant was also determined. Data were analysed using the Costat computer package. Means were separated using the Tukey-Kramer test.

**Research Application**

The general routine soil analysis showed that nearly all the soils had low levels of organic matter, phosphorus and total nitrogen. But soil potassium levels were optimal except in three fields. High to very high levels of copper and iron were found in all the soils. Zinc was the only micronutrient that was found to be deficient in the sampled soils but this was only in three out of 15 fields.

The CIMMYT Harvestplus Programme come up with target levels for micronutrient levels in grains. The target zinc and iron concentrations in maize grain are given as 38 ppm and 60 ppm, respectively (Welch and Bouis, 2009). The rated maize grain zinc and iron levels are shown in Table 1. The sampled maize grain zinc and iron contents were all lower than the target levels.

**Table 1. Rated maize grain micronutrient content for human dietary needs.**

| Farmer | Area | Zn µg/g | Fe µg/g |
|---|---|---|---|
| Shikuru Kikunde | Mkuyuni | 14.5*1 | 19.2*1 |
| Shabani Mayumba | Mkuyuni | 20.8*1 | 46.2*1 |
| Mdengo | Mikese | 14.0*1 | 30.8*1 |
| Mama Mweleza | Mikese | 17.4*1 | 30.8*1 |
| Mama Goreta | Mikesa | 10.1*1 | 19.2*1 |
| SUA maize | SUA | 50.3*h | 19.2*1 |
| Lusillu | Ruvuma | 13.0*1 | 46.2*1 |
| Mlema Ukae | Ruvuma | 8.2*1 | 19.2*1 |
| Isa | Ruvuma | 15.9*1 | 30.8*1 |
| Nuwia | Ruvuma | 8.7*1 | 19.2*1 |

NB: *l and *h indicate low, and high levels of the nutrient elements in beans according to ratings by (Welch and Bouis, 2009).

Correlations between soil and grain zinc, iron and copper were 0.194, 0.308 and 0.247, respectively. Though not significant ($P<0.05$) these correlations were positive and represented weak associations between soil levels of the mentioned micronutrients and their levels in grain. It can be interpreted that increased levels of these micronutrients increased their accumulation in maize grain.

**Screenhouse experiment.** Only crops grown on Mikese soil showed significant differences in plant biomass, with the control having the lowest. However, in both soils the control plants were smaller and chlorotic. Whole plant analysis showed that only the plants grown on the Mikese soils (which had a zinc soil deficiency) responded to soil fertilisation when it came to zinc accumulation and increases in plant biomass. Overall, significant differences were observed amongst the treatment means. Zinc levels and plant biomass increased with increased soil fertilisation with the addition of NPK only. Plants grown on both soils (Mlali and Mikese) showed a negative response in iron accumulation and soil fertilisation. This was, however, more evident in crops grown on Mikese soil. Bean seeds, however, showed no significant differences (P<0.05) in levels of seed micronutrient concentrations amongst all treatment means for both soils (Table 2). Significant differences (P<0.05) were, however, found between the seed weight per plant from seed collected from plants grown by farmers on Mikese soils. The control had the lowest seed weight.

**Table 2. Biomass weights and nutrient contents of beans grown on Mlali and Mikese soil.**

| Control | Mlali | | | Mikese | | |
|---|---|---|---|---|---|---|
| | Seed weight | Zn µg/g | Fe µg/g | Seed weight | Zn µg/g | Fe µg/g |
| | 0.47a | 43.3a*1 | 237.3 a*o | 0.65c | 41.6 a*1 | 246.4 a*o |
| NPK | 4.03a | 29.4a*1 | 346.4 a*o | 3.00b | 31.9 a*1 | 192.0 a*o |
| NPK+ 7.5 Zn | 2.16a | 30.4a*1 | 158.5 a*o | 4.97a | 39.4 a*1 | 187.3 a*o |
| NPK + 15 Zn | 2.50a | 29.6 a*1 | 152.4 a*o | 5.38a | 28.9 a*1 | 158.5 a*o |
| NPK + 15 Zn + 7.5 Fe | 4.13a | 25.2 a*1 | 203.9 a*o | 4.57a | 19.8 a*1 | 161.5 a*o |
| NPK + 15 Zn + 15 Fe | 3.57a | 26.5 a*1 | 203.9 a*o | 5.23a | 26.8 a*1 | 173.6 a*o |
| NPK + 15 Zn + 15 Fe + 5 Cu | 1.92a | 44.2 a*1 | 179.7 a*o | 3.90a | 20.7 a*1 | 182.7 a*o |
| NPK + 15 Zn + 15 Fe + 10 Cu | 1.98 | 39.0 a*1 | 216.1 a*o | 3.98b | 30.0 a*1 | 158.5 a*o |

Means within a column followed by the same letter are not significantly (P=0.05) different according to the Tukey-Kramer test. *1, *o and *h indicate low, optimal and high levels of the nutrient elements in beans according to ratings by Welch and Bouis (2009).

The bean seeds were not enriched with the micronutrients zinc and iron. Targeted levels for zinc and iron in beans are 56µg/g and 107µg/g, respectively (Welch and Bouis, 2009). The zinc treatment means were all lower than this value. The iron concentrations were, however, all higher than the target level including the control. This showed that there was no response of iron accumulation in seed due to the fertiliser treatments.

## Recommendation

Maize grain produced in the selected parts of Morogoro region was deficient in dietary human zinc and iron. The soils, on the other hand, were mainly deficient in macronutrients. The addition of NPK-fertilisers increased yields and aided plant micronutrient uptake. Soil zinc may likely be a greater problem in the near future if nothing is done to increase its level in the study area. Copper and iron are more than abundant in these soils despite their low levels in the grains. Thus, soils factors limiting their uptake should be determined and eliminated.

## Acknowledgement

This study was funded by SADC-ICART as part of the first author's M.Sc. study.

## References

AGRA (Alliance for a Green Revolution in Africa), 2010. AGRA's Soil Health Program. [http://www.agra-alliance.org/section/work/soils] site visited on 29/6/2010.

Down to Earth, 2010. Minerals: The overlooked necessity. [http://www.downtoearth.org/health/nutrition/minerals-overlooked-necessity] site visited on 28/6/2010.

PureNewYouSoil.com 2010. Mineral depletion. [www.purenewyou.com/shop/index.php?main_page...] site visited on 28/06/2010.

Marler, J.B. and Wallin, J.R. 2006. Human health, the nutritional quality of harvested food and sustainable farming systems. Nutrition Security Institute. [http://www.nutritionsecurity.org/PDF/NSI_White%20Paper_Web.pdf] site visited on 28/6/2010.

Mtambanengwe, F., Kosina, P. and Jones, J. 2007. Beyond NPK - the importance of micronutrients to maize growth. site visited on 23/7/2009.

Roy, R.N., Misra, R.V., Lesschen, J.P. and Smaling, E.M. 2003. Assessment of soil nutrient balance. Approaches and methodologies. FAO Fertilizer and Plant Nutrition Bulletin 14.