Food Systems Summit 2021

Action Track 1: Ensuring Access to Safe and Nutritious Food for All

Re-thinking the Role of Plant Nutrients

While the Green Revolution in the 1960s marked a turning point in the performance of food systems, pressures on health, ecosystems, biodiversity and the climate are on a continuous rise. Over 2 billion people still do not have regular access to safe, nutritious, and sufficient food, and 3 billion cannot afford the cheapest healthy diet (*1*). There is a strong link between human nutrition and the mineral nutrient content of soils and plants, as plants are the primary source of nutrients for both humans and animals.

The new paradigm of **responsible plant nutrition** encompasses a broad array of scientific and engineering know-how, technologies, agronomic practices, business models and policies that directly or indirectly affect the production and utilization of mineral nutrients in agri-food systems. Following a food system approach, responsible plant nutrition aims to (*2*):

A. Improve income, productivity, nutrient efficiency and resilience of farmers and businesses supporting them
B. Increase nutrient recovery and recycling from waste and other under-utilized resources
C. Lift and sustain soil health
D. Enhance human nutrition and health through nutrition-sensitive agriculture
E. Minimize greenhouse gas emissions, nutrient pollution and biodiversity loss

Therefore, one of the most straightforward, impactful and transformative actions to improve food systems should start at the crop production level. Diversification of cropping systems and the optimized use and, if necessary, enrichment of fertilizers, is one of the most straightforward solutions to address hunger, stunting and other forms of malnutrition, but also enable healthier human diets in well-developed economies. Mineral fertilizers provide essential macro- and micronutrients to plants, which in turn are passed on to people when consumed: ***Fertilizers do not only assure the quantity, but also the quality of plant-based food.***

Key Messages:

- **The question of food security cannot be limited anymore to the amount of crops we grow but needs to be looked at through the lens of crop quality for human and animal health.**
- **Because fertilizers and other sources of nutrients are an integral component of human nutrition and health, a paradigm shift must happen in the way they are perceived, managed, regulated and incentivized.**
- **A shift in the perception of fertilizers from "inputs to plants" to "inputs to human diets" allows the better prioritization of their nutritional outcomes for humans. Plant nutrition has to become an integral part of national food, nutrition and health policies.**
- **Concrete solutions exist for implementing nutrition-sensitive agriculture, including fertilizer-based interventions.**

Changing our thinking: better plant nutrition for healthier diets

Plant nutrients are much more than agricultural inputs: by growing crops for human and animal consumption they help provide essential calories, proteins, vitamins, minerals, dietary fiber, antioxidants and other bioactive compounds of importance for human nutrition and health (*3, 4*).

As a precondition for growth, health and the production of nutritious food, plants require 14 essential mineral nutrients in sufficient quantities[1]. These nutrients can be provided by mineral, organic or organo-mineral fertilizers, as well as through natural processes such as biological nitrogen fixation or the weathering of soil minerals. In addition, some micronutrients essential to animal and human health such as selenium (Se), iodine (I) and cobalt (Co) are not considered essential for plants but can be taken up and accumulated by plants. Hence, humans directly benefit from balanced plant nutrition, but also crops or pastureland used for livestock production provide the basis for highly nutritious meat, milk and other animal-derived products.

Fertilizer programs implemented in the past mainly focused on improving soil fertility and crop yields to increase farm incomes, with the main emphasis given to nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) fertilizers (i.e. macronutrients found in plants at levels of about 2 to 50 g/kg of dry matter). Less attention has been paid to nutritional outcomes for human health, despite the important links between plant nutrition, health and dietary intakes of nutrients which recent studies have highlighted. In the United States, for example, a constant decline in ratios of K fertilizer and removals in crops has led to a decline in dietary K intake in the US population and a rise of hypokalemia, a human illness caused by low levels of potassium in the blood serum (*5*). in 2011, 3.5 and 1.1 billion people were at risk of calcium (Ca) and zinc (Zn) deficiency respectively, due to inadequate dietary supply, mostly in Africa and Asia (*6*).

A handful of micronutrient-poor crops dominate the global food and feed chains and have often decreased crop diversity or displaced traditional crops such as pulses (*7*). Owing to often insufficient micronutrient (i.e. nutrients that concentrate in plants at a range of 0.1 to 100 µg/kg) fertilization, the steady growth of crop yields in recent decades has compounded the problem by depleting micronutrient concentrations in grains and soils, although, thus far the benefits of increased yields to supply food for a growing population appear to outweigh such nutrient dilution effects (*8*). However, in sub-Saharan Africa, for example, significant relationships can be found between soil nutrients and child mortality, stunting, wasting and underweight (*9*).

Micronutrient deficiencies affect an estimated 2 billion people in the world. Iron (Fe), zinc (Zn), selenium (Se) and iodine (I) deficiencies are well-documented problems, affecting both human and animal health, and also impacting agricultural productivity. Yields can be affected by deficiencies that impair the physiological processes related to seed formation, synthesis and the distribution of carbohydrates, biological nitrogen fixation and plant resistance to biotic and abiotic diseases. Zinc deficiency is common in up to 50% of wheat-cultivated soils worldwide (*10*) and large areas of agricultural soils are also deficient

[1] Nitrogen (N), phosphorus (P), potassium (K), sulphur (S), magnesium (Mg), calcium (Ca), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo), chlorine (Cl), nickel (Ni). Furthermore, additional elements may be essential to a few plant species, e.g. sodium (Na) and cobalt (Co).

in iron. Most of the earth's surface is iodine deficient (*11*). Soil selenium concentrations are dominated by climate–soil interactions, and climate change is likely to further increase the risk of Se-deficiencies (*12*). Livestock health, productivity and product quality directly depend on a balanced supply of micronutrients from crops fed to animals and pastures used for grazing (*13*).

Breaking down the silos: nutrition-sensitive agriculture

Optimized nutrient management solutions must focus on the whole nutritional contribution of food crops: producing affordable and healthier food for everyone.

Food systems have become increasingly globalized and interdependent, and diets around the world can be expected to keep changing (*14*). **Nutrition-sensitive agriculture** is a food-based approach to agricultural development that puts nutritionally rich foods, dietary diversity, and food fortification at the heart of overcoming malnutrition and micronutrient deficiencies. Making agriculture more nutrition-sensitive requires a new way of thinking, planning, implementing, and partnering (*15*). Nutrition and health outcomes need to be systematically embedded in agricultural and other policies, including integration of education and extension programs targeting farmers and consumers (*16*). Promoting the diversification of production in the field, improved food processing, healthier diets, or other interventions along the supply chain requires good collaboration among the concerned sectors and actors.

Critical entry points where nutrition goals can be best incorporated into agri-food systems must be clearly identified. Nutrition-sensitive agricultural programs and policies will not be successful if the targeted nutrients are missing in soils and/or in the edible plant parts at desirable levels for animal and human nutrition. In Africa, for example, statistically significant relations can be found between soil nutrients and child mortality, stunting, wasting and underweight (*9*). Therefore, fertilizers – both mineral and organic fertilizers – play a key role in helping to sustainably diversify and intensify agricultural production and through that achieve better nutritional and health outcomes. At the same time, it is also vital that impurities in fertilizers do not adversely affect soil or food quality, with cadmium being the element requiring most careful management in mineral fertilizers (*17*).

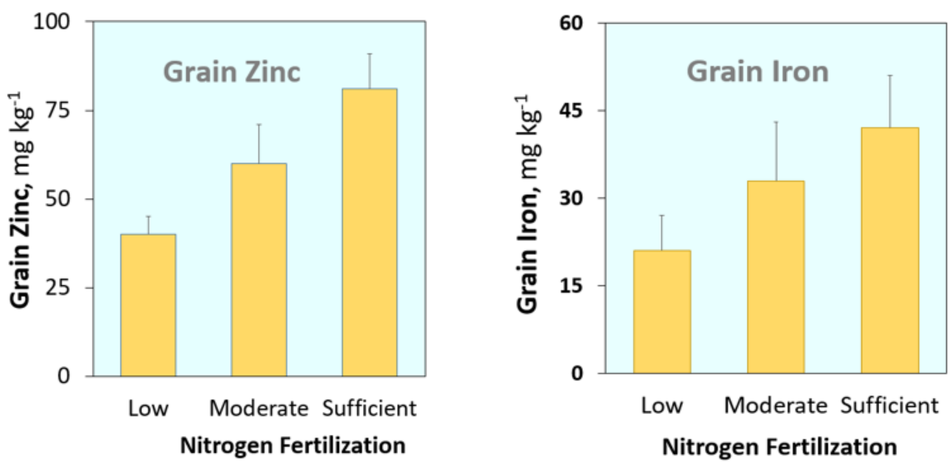
The fertilizer industry therefore calls on governments to **support nutrition-sensitive agriculture** by:

1. **Prioritizing a sustainable intensification and diversification of cropping systems** aiming to close existing yield gaps, produce high-quality, nutritious crops, and increase the nutritional output through better diversity of cropping systems and crops grown. The balanced supply of nutrients from fertilizers and other sources is a key requirement for that. This also supports changes in land use to respond to new market demands due to changing diets, provide nutritious food to local populations, address changing climatic conditions, improve biodiversity, or save water and other natural resources.
2. **Promoting a targeted enrichment of local staple food crops with micronutrients where it is most needed.** A broad and multi-intervention strategy should be put in place to lift up the basic supply of micronutrients and reach deep in the poorer-income segments of countries with lingering malnutrition problems.
3. **Improving the health and wellbeing of livestock.** Nutrient-rich pastures, grain and other feedstuff contribute to enhancing the biochemical richness of meat and dairy products, resulting in

increased nutrient availability to humans, and a better quality and shelf life of products, thus also reducing food waste.

Prioritizing agricultural policies to help farmers to change their land use and adapt to a new environmental, social and/or economic reality should be done in close cooperation with national health and environmental agencies. This allows to ensure a stronger end-to-end connectivity between farmers and consumers.

In the context of nutrition-sensitive agriculture, plant nutrients can be managed in a manner that focuses on crop requirements and exploits the interactions of mineral nutrients in soils and plants (*18*) to achieve multiple economic, food security and nutrition outcomes. For example, an optimal nitrogen fertilization of crops will ensure high yield and protein content, but it also increases the concentration of micronutrients in plants' grains:



Effect of nitrogen fertilization on grain zinc and iron concentration in wheat (*19*).

Numerous studies have also shown that balanced fertilization, i.e. giving the proper supply of all macronutrients and micronutrients in a balanced ratio throughout the growth of crops, helps crops become more resilient to drought, heat, winds and storms, pests and diseases.

Hence, the key to success are **well-tailored fertilizer best management practices that follow the 4Rs principles (*20*):** using the right source of nutrients, at the right rate, at the right time and in the right place. Implementing the 4Rs has demonstrated that crop yield, quality and nutrient use efficiency are improved, while nutrient losses to the environment are minimized. Besides high-tech 4R solutions for commercial farming, "low-tech" site-specific nutrient management approaches have shown consistent, large increases in crop yields and profits and nutrient use efficiency in many crops grown by smallholder farmers in Asia and Africa (*21, 22*). Particularly in sub-Saharan Africa, integrated soil fertility management (ISFM) approaches combine the use of mineral and organic nutrient sources with good soil management practices, cropping systems, choice of suitable crop varieties, and other agronomic practices (*23*).

Biofortification solutions

One major strategy to minimize the extent of micronutrient deficiencies in human populations in a targeted manner is the enrichment (**biofortification**) of staple food crops with micronutrients, which can be done through genetic improvement (breeding), the enrichment of fertilizers, or a combination of both (*7, 10, 24, 25*). New crops such as the drought-resistant, vitamin A-biofortified sweet potato in sub-Saharan Africa, have a big potential to improve their consumers' health, but can also strengthen the food and income security of the poorest households which have no access to irrigation (*26*). In an effort to reduce Hidden Hunger in the most affected countries and help farmers increase their yields and incomes, the international project HarvestPlus has released 242 biofortified crop varieties in 30 countries, including vitamin A maize and cassava, iron-enriched beans, and zinc-enriched rice and wheat (*27*).

Agronomic biofortification, on the other hand, is defined as the application of mineral micronutrient fertilizers to soils or plant leaves (foliar application) with the objective of increasing the micronutrient content in the edible part of the crops. It has the advantage of getting a relatively fast response with good bioavailability of the micronutrients applied, and it can be used in a complementary manner with genetic or food fortification (e.g. supplementing salt, flour or processed food with micronutrients).

Evidence suggests that **agronomic biofortification with selected micronutrient fertilizers, such as Zn, Fe, Se and iodine is an effective and sustainable way to reduce deficiencies in populations around the world**. Several concrete solutions are well-tested and ready to be scaled up:

Supplementing fertilizers with selenium

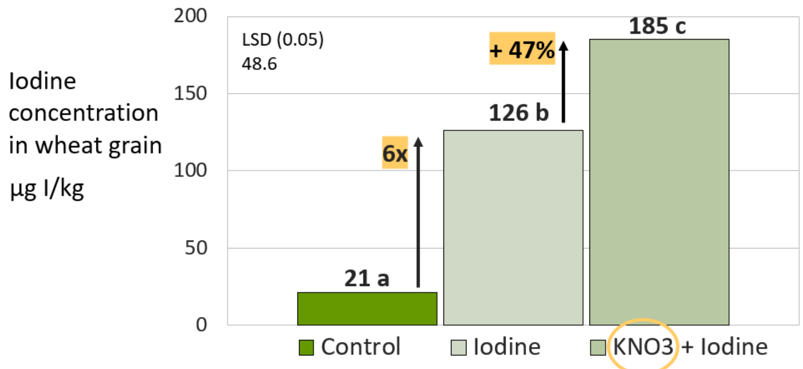
Soils in the Nordic European countries are naturally low in selenium. In 1984, Finland addressed the widespread selenium (Se) deficiencies in people through a country-wide measure, requiring that all mineral fertilizers must contain 15 mg Se/kg. This mandatory practice has led to a 15-fold increase in Se concentration of spring cereals, resulting in effective and safe increases in Se intake and the health of the whole population (*28*). Dietary human intake increased from 0.04 mg Se/day to a new plateau of 0.08 mg Se/day, above the current nutrition recommendations. The UK also uses Se fertilization sporadically to improve human health and New Zealand supplements fertilizers with Se to improve livestock health.

Using zinc-enriched fertilizers at the right time

The use of Zn-enriched fertilizer (for instance Zn-coated urea, Zn-enriched NPK, or liquid fertilizers for foliar application) has demonstrated significant increases in yields and Zn concentrations in rice and wheat grown in different regions (*29*). Rapid increases in zinc density in grain are particularly obtained through foliar applications at critical growth stages (*10, 30*). In Pakistan and India, where wheat is consumed widely, efforts concentrate on releasing "High-Zinc" varieties in order to combat human Zn deficiencies, as the primary route of intake is from food sources. The best levels of Zn enrichment can be achieved through a combination of genetic and agronomic biofortification, i.e. the site-specific use of high-Zn varieties together with Zn-containing fertilizers (*31*). In the Philippines, biofortified rice genotypes achieved grain yield and grain Zn targets (30 mg/kg for brown rice) only when grown under Zn-sufficient soil and fertilizer conditions (*32*).

Increasing iodine density in cereals

IFA Member company SQM partnered with the international research project HarvestZinc to develop a foliar solution of iodine combined with potassium nitrate to achieve optimal grain iodine concentration in rice or wheat:



The biofortified wheat grains are passed on to humans through flour and bread, and can increase people's iodine intake 4-11 fold (*33*). This solution can be deployed in small and large food systems where processing and distribution are effective:

Tackling multiple micronutrient deficiencies

The HarvestZinc project has demonstrated how foliar applications of micronutrient cocktails can simultaneously increase the contents Zn, I, Se and Fe in the grains of different wheat cultivars under various agro-ecological conditions, in China, India, Mexico, Pakistan, South Africa and Turkey (*34*).

The root causes of micronutrient deficiencies in human populations, which are the low amount of micronutrients in agricultural soils and in commonly-consumed diets, must be addressed in agricultural and food policies embedding nutrition as a focus area (*16*). **Food fortification measures should always be adapted to the local context and designed to address the real causes of the micronutrient deficiencies**. Exploiting the full nutritional benefits of these plant nutrition innovations will require greater policy support, good targeting, integration with other interventions and strategic cooperation with the fertilizer industry. The wider adoption of biofortification practices by farmers depends on economic incentives, legislative mandates and extension services that provide the necessary transfer and assurance, linking agricultural and nutritional training and extension.

Conclusions

- The fertilizer industry supports a new paradigm for plant nutrition that does not only focus on productivity for food security, rural development and the environment, but also includes nutrition and health as one of the Food Systems principles.
- Governments should follow "One Nutrition" strategies that are based on the linkages between soil, crop, animal and human health.
- The fertilizer industry recommends that governments prioritize nutrition-sensitive agriculture, and work with the industry and scientific communities to design and implement plant nutrition solutions tailored to national nutrition needs, with a particular emphasis on micronutrients.
- Diverse interests and investments should be aligned through a "Farm to Fork" strategy that involves all key stakeholders:
    - Food producing & processing companies produce, procure and sell more nutrient-rich food to the end consumer, and benefit from their own marketing efforts.
    - New business strategies in the agri-food sector could center around nutrition-enhancing investment tools.
    - The fertilizer industry should use nutrition performance as a new business model, ensuring that nutrition is embedded in marketing and extension efforts worldwide.
    - Farmers are supported technically and financially for investing in shifting to more diverse crops and adopting new fortification technologies.
    - New business strategies in the agri-food sector could center around nutrition-enhancing investment tools. Financing schemes that combine private investments with public funding should support special biofortification and nutrient enrichment programs on the farm.
- More research should focus on the effect of climate change on the nutritional output and quality of crops to provide guidance for better and more adapted land-use, changes in cropping systems, or other adaptation measures.

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