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Soil-Plant-Animal-Human Continuum for Sustaining Food and Nutrition Security

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News Story

Abstract

In general, agriculture is the primary supplier of food and nutrients to all humans on the earth. Nutrients play a key role in the growth and development of plants, animals, and humans. Macronutrient's water, carbohydrates, fats, proteins, vitamins, and some mineral elements phosphorus (P), potash (K), sodium (Na), calcium (Ca), chlorine (Cl), magnesium (Mg), and sulfur (S) and trace elements fluorine (F), silicon (Si), vanadium (V), chromium (Cr), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), arsenic (As), selenium (Se), molybdenum (Mo), and iodine (I) are essential for the maintenance of a healthy system. Macronutrients i.e., carbon, hydrogen, and nitrogen, and micronutrients like zinc, copper, iron, manganese, boron, molybdenum, chlorine, nickel, cobalt for legumes only, essential for plants, are also essential to humans. Iodine, selenium, fluorine, and chromium are essential for humans but not for plants, nevertheless absorbed by plants from soil and water and enter into the animals and humans through food chains. Macro and micronutrients application has not only contributed to enhancing the food grain production and also helped in sustaining soil health and fortifying the country's nutritional security.

Introduction

India has vast agricultural potential and prospects in agriculture-led industrial development, the country faces a set of issues related to minerals and trace elements in its food chain (soil-plant-animal-human). All organisms require a minimum amount of nutrients to maintain good health and productivity. Besides building block elements for macronutrients (water, carbohydrates, fats and proteins) and vitamins, some mineral elements phosphorus, potash, sodium, calcium, chlorine, magnesium and sulphur and trace elements fluorine, silicon, vanadium, chromium, manganese, iron, cobalt, nickel, copper, zinc, arsenic, selenium, molybdenum, and iodine are essential for the maintenance of a healthy system (Shukla, *et al.*, 2018). Micronutrient deficiency or excess in any of these elements in the food chain may lead to undesirable conditions that should be prevented or reversed. It is well said that health is wealthy and a healthy life is not possible without healthy soils. Good soils are the foundation for meeting our basic needs for food, fuel, fiber, and medicine. Soil health is critical to ecosystem functioning, since it plays a key role in the carbon cycle, storing and filtering water, and adaptation to and mitigation of climate change. In the face of the mounting challenge of feeding a projected population of 9.6 billion by 2050 under the growing threat of climate change-induced extreme weather events, soil health becomes quite critical for our future survival. Soil influences human health in a variety of ways, with human health being linked to the health of the soil. Historically, emphasis has been placed on the negative impacts that soils have on human health, including exposures to toxins and pathogenic organisms or the problems created by growing crops in nutrient-deficient soils. However, there are a number of positive ways that soils enhance human health, from food production and nutrient supply to the supply of medications and enhancement of the immune system. India faces a wide set of soil fertility challenges including organic matter depletion, macronutrient, and micronutrient depletion, topsoil erosion, acidity, and salinity. The soil system is deficient in total nitrogen, available phosphorous, sulfur, zinc, and copper. Livestock productions, which depend on less dense nutrient crop residues, are less likely to supply essential dietary minerals. Besides, vitamin A, calcium, iodine, iron, zinc, and selenium deficiencies have been found to be major public health problems. Food and fodder produced on these soils without supplementation of deficient micronutrient(s) have poor trace element concentration, causing micronutrient malnutrition in animals and humans alike. Even though the levels of trace elements like Cu, Zn, Mn, Fe, Mo, Se and Co in crops are sometimes sufficient for optimum yields but they are sub-optimal to meet the needs of livestock leading to their widespread deficiencies. Widespread nutritional deficiencies of vitamin A, Fe, Zn, and iodine affecting human health, disproportionately especially women and young children, have been reported. Soil-related deficiencies of trace elements such as Se, Cu, Fe and Zn are also implicated as causal factors for anemia. Holistic approach is required to develop sustainable technologies to reduce nutrient malnutrition by launching a mission mode programme on macro/micronutrient research in soil-plant-animal/human continuum mode.

Impact of minerals and trace elements status in plants, foods and vegetables

In addition to carbon, hydrogen, and oxygen, major macro-elements (N, P, and K), secondary macro-elements (Ca, Mg, and S), and microelements (B, Cl, Cu, Fe, Mn, Mo, and Zn) are essential for the healthy growth of higher plants (Girma, 2016). If one or more of these elements is deficient, crops will fail to achieve their optimum yields and the quality of their food products is likely to be diminished. In order to provide adequate and quality food for the population, micronutrient deficiencies in agricultural and horticultural crops should be identified and treated wherever they are found. Micronutrient deficiencies in crops occur all over the world including in different areas in India. In addition to the decrease in yields, the contents of micronutrients in crop products such as staple grains for humans or livestock foliage for animals are also of great importance to the health of human and livestock consumers, respectively. Nutrient availability to people or livestock is primarily determined by the output of feed produced from agricultural systems. Many factors such as variety, soil conditions, use of fertilizers, and degree of maturity during harvest and preparation methods affect mineral concentrations of the plants or plant-based foods available for consumption (Shukla *et al.*, 2014).

Impact of minerals and trace elements status in animals

Reproductive well-being and performance of livestock are determined by four factors: genetic merit, physical environment, nutrition, and management. India's livestock is contributing little in ensuring food security, mainly attributed to poor feed quality and unavailability of animal quality feed. Livestock productivity in the country is below the developed country's average. Evidence from the literature suggests that socio-economic and technical factors including genetic, health, and feed quantity and quality directly affect livestock production in the country (Girma, 2016).

Impact of minerals and trace elements status in the populations

In fact, an integral link between soil and human health was recognized several thousand years ago, that good human health is linked with healthy soils, which produce a variety of food. A reference to geophagia, soil ingestion, in India dates back to Mahabharata (3200 BC) where Balarama and the other friends complained to Mata Yasoda that Krishna had eaten the soil. The Mesopotamian civilizations and collapse of the Indus valley civilization in 2000 BC have been attributed in part to soil degradation brought about by erosion and salinization. Maya empire in approximately 600 AD may have collapsed due to soil nutrient exhaustion, erosion, and resulting malnutrition (Olson, 1981).

An estimated 40% of the world's population, mostly in low-income countries is facing a problem of micronutrient malnutrition (Shukla *et al.*, 2014). The deficiency of essential minerals and trace elements in infants and schoolchildren, women of reproductive age, pregnant and lactating women, and the elderly is recognized as a major public health problem in many developing countries. Unavailability or inadequate intakes of dietary micronutrients arising from low intakes and/or poor bioavailability is the major factor in the aetiology of micronutrient deficiencies in developing countries where the vast majority of the population depends on plant-based diets. Trace elements in plant-based foods are less bioavailable for human metabolism due to the presence of chelators, phytates, and dietary fiber, which inhibit absorption. Children and women are particularly vulnerable to nutritional deficiencies because of the increased metabolic demands imposed by rapid growth and development in children and pregnancy involving a growing placenta, fetus, and maternal tissues, coupled with associated dietary risks. The deficiency of micronutrients in infants and young children may cause compromised growth, failure to thrive, and impaired cognitive functions (Girma, 2016).

Strategies to improve macro/micronutrient deficiencies

The high occurrence of micronutrient deficiencies in India warrants the need for strategies for the prevention and control of the deficiencies. Even under the best of circumstances, the current Indian diet cannot fulfil all nutrient requirements and additional interventions are required. Difficulties pertaining to deficiency and toxicity of micronutrients in animal and human health emanate from the low and very high flow of these elements to animals and humans through the soil-water plant-animal-human food chain in different geographical areas. Classical examples include the relationship between goiter and lack of iodine, caries, deficiency of F, dwarfism, and lack of Zn. Soil is the major source supplying micro-nutrient elements to the food chain. Cereals namely, rice and wheat are grown in Zn- and Fe deficient soils produce grains in low Zn and Fe content. Consequently, the cereal-based food/diet, which contributes 70 % of the daily calorie intake of the poor population, is also low in Zn and Fe concentration. Recent approaches are used to manage and/or prevent Fe and Zn deficiency and improve their status in humans (Shukla *et al.*, 2014). Proven and inexpensive technologies and intervention types, such as behavioural, fortification, supplementation, regulatory, and other health-related interventions exist to address malnutrition and micronutrient deficiency in a population. Strong behavioural changes and practices to diversify diets to include animal-based foods, fruits and vegetables have demonstrated better results in children. Regulatory interventions are those aimed at regulating certain nutrition-related activities or actions, which have an impact on nutrition and health

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outcomes. Other health-related interventions, such as breastfeeding, deworming and prevention of infections also have an impact on nutrition. A new approach, biofortification via agriculture (agronomic biofortification) or plant breeding (genetic engineering or genetic biofortification) has been shown to also be a good strategy (Girma, 2016).

Lastly, a roadmap has to be established for the acceptance of proven micronutrient technologies to combat their deficiencies in specific soil-crop systems to achieve the targeted production of 380-400 mt of food grain by 2030 besides ensuring higher use efficiency of macronutrients and other inputs. This would only be possible if effective knowledge-driven coordinated efforts are made by different several agencies in providing advisory services to the farmers. The development of new fertilizer strategies to deliver the required nutrients in food systems sustainably is needed to address the micronutrients problem in the soil-plant animal/ human continuum (Shukla *et al.*, 2014).

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