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Macro Focus on MicroNutrients

Looking back the history, to sustain the life, mankind was completely depended on hunting and gathering. When the exponential increase of population started, the food needs also got increased which paved a way for organized agricultural practices with its core focus on food security. Over last few years, the risk of death rates due to famine and food shortages have been decreased gradually but the micronutrient malnutrition status has been increased. It shows that the food needs of the population got its necessary focus whereas the balanced diet didn't. A balanced diet should contain adequate quantity of macro and micro nutrients that a human requires in a day. The awareness and usage of macronutrients in food has got its importance whereas the micronutrients were often neglected. An attempt has made to furnish the role and importance of micronutrient in soil, plant or human health.

INTRODUCTION

Micronutrients play a vital role in proper growth and development of the human body. The deficiency of micronutrients affects the human health which leads to the occurrence of micronutrient malnutrition in children and women extensively. This micronutrient malnutrition is considered as a 'hidden hunger' which is a public health problem that affects more than one fourth of the global population (Gonmei and Toteja, 2018). This can be alleviated by taking proper diet or through supplements. The status of micronutrient malnutrition can be monitored through the micronutrient chain (Figure 1) i.e. if the soil is loaded up with required micronutrients then the plants grown on the soil will contain required micronutrient, if the plant contains adequate micronutrient then the human who consumes it gets supplied with required micronutrient. Hence, the knowledge on the forms and deficiency of micronutrients in soil and plants will help us in alleviating the micronutrient malnutrition in human so that the micronutrient deficiency chain can be stopped easily and we can move towards a hidden hunger free world.

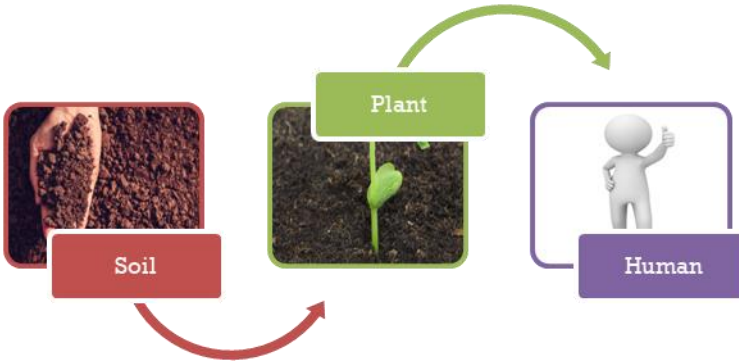

Figure 1. Micronutrient chain

SOIL MICRONUTRIENTS

All the creatures of this universe derive their nutrient needs from the soil directly or indirectly. In nature,

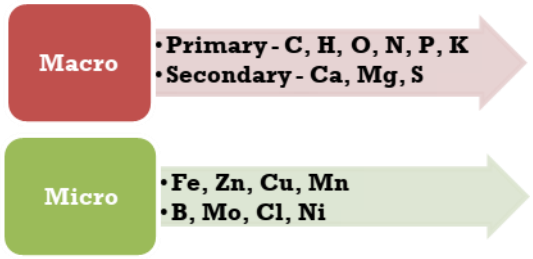

Figure 2. Essential nutrients

there are 17 essential nutrients (Figure 2) which are classified into macro (primary and secondary) and micro nutrients. The role and need of macro nutrients got its attention in agricultural production and now it is time to turn towards micronutrients. The concentration of micronutrients in soil is very low but the role of micronutrients is equally important to macro nutrients. Globally, on an average 49, 31, 15, 14, 10 and 3 per cent of soils are deficient in Zn, B, Mo, Cu, Mn and Fe, respectively (IZA 2019). Basic knowledge on the forms of micronutrient in soil, availability of micronutrients in minerals, mobility of micronutrient in soil and factors affecting the micronutrients will help us to know about the nature of soil micronutrients.

FORMS AND AVAILABILITY OF SOIL MICRONUTRIENTS

The soil micronutrients may present in different forms in soil which is called as soil micronutrient pools (Figure 3). In soil solution pool, the ions are readily available to the plant growth whereas in the exchange and adsorption pool, the adsorbed ions are tending to exchange with some of the solution forms or with organic or mineral bound pools (cation or anion exchange). In organic matter bound pool, the cationic and anionic forms of micronutrients get adsorbed to the organic residues through chelation mechanism. Chelation is a process in which an inorganic nutrient gets enclosed by an organic and synthetic molecule like a claw.

In minerals and precipitates pool, the micronutrients gets occluded in the minerals or the micronutrients may be present naturally in the minerals during the formation of rocks. This pool may take more time to release its micronutrients when compared with the other pools. Soil solution is the

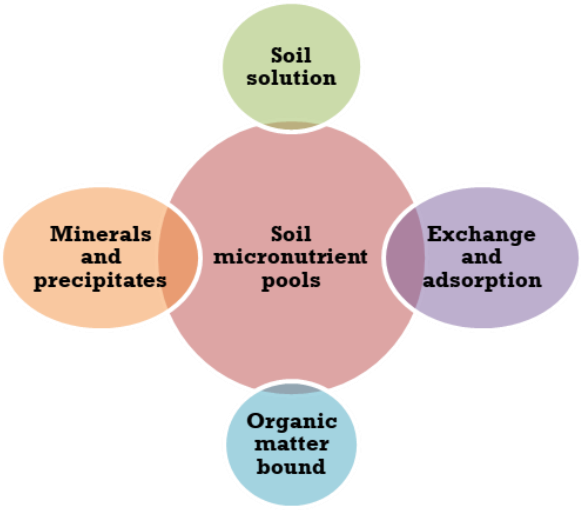

Figure 3. Soil micronutrient pools

readily available pool and the mineral pool is the highly fixed pool in which the micronutrients can't get released easily. Micronutrients may present both in cationic and anionic forms in the soil. Micronutrients like iron, zinc, copper and manganese occurs in cationic form whereas boron, molybdenum and chlorine occur in anionic form in the soil (Table 1).

MOBILITY OF SOIL MICRONUTRIENTS

Nutrient mobility is the speed at which nutrients can move throughout the soil profile which impacts nutrient uptake. The mobility of nutrients gets varied from one another. In soil we can observe mobile and relatively mobile micronutrients (Table 2). The mobile micronutrients are moved in the soil to the root surface through mass-flow (flow of nutrients with

Table1. Availability of micronutrients in minerals and soil micronutrient forms

Sl. No.	Micronutrient	Mineral	Soil nutrient form
1.	Iron (Fe)	Olivene, Siderite, Hematite, Magnetite	Fe^{2+}, Fe^{3+}
2.	Zinc (Zn)	Franklinite, Smithsonite, Willemite	Zn^{2+}
3.	Copper (Cu)	Malachite, Cupric ferrite	Cu^{2+}
4.	Manganese (Mn)	Pyrolusite, Hausmannite, Manganite	Mn^{2+}
5.	Boron (B)	Tourmaline	BO_3^{2-}, H_3BO_3, $H_2BO_3^-$
6.	Molybdenum (Mo)	Wulfenite, Powellite	MoO_4^{2-}
7.	Chlorine (Cl)	Sodium chloride, Calcium chloride	Cl^-
8.	Nickel (Ni)	Garnierite	Ni^{2+}

water) whereas the immobile micronutrients move to the root surface through diffusion (flow of nutrients from higher to lower concentration).

Table 2. Mobility of micronutrients in soil

Mobile	Relatively mobile
H_3BO_3, $H_2BO_3^-$	Cu^{2+}
Cl^-	Fe^{2+}, Fe^{3+}
	Mn^{2+}
	MoO_4^{2-}
	Zn^{2+}
	Ni^{2+}

FACTORS AFFECTING SOIL MICRONUTRIENTS

The actual relative mobility of each micronutrient depends on pH, moisture, texture and organic matter of soil.

Soil pH	The availability of micronutrients depends on the pH, at acidic condition the Fe^{2+} and Fe^{3+} ions gets precipitated. Molybdenum ions are available in alkaline condition. In general, all the micronutrients will be in available form at a pH range from 6 to 7.5.
Soil moisture	Excessive water and poor aeration hinder the nutrient transformations and affects the micronutrient release and uptake.
Soil texture	Sandy textured soil have low surface area so the water and nutrient holding capacity of the soil will be low whereas the nutrient and water holding capacity of the soil gets increased with the increasing clay content.
Soil organic matter	Organic matter has higher surface area which helps in holding and supplying the micronutrients to plants. The decomposition of organic matter helps in releasing some of the bound micronutrients to the plants.

PLANT MICRONUTRIENTS

As Arnon and Stout (1939) stated, each and every nutrient has its own definite function in the plant growth (Table 3) and the deficiency of one nutrient will show it symptoms and cannot be altered by the other nutrient. This suits for micronutrients too; the role of essential micronutrient varies from each other. The concentration of micronutrients is less than 0.025 per cent or 250 ppm of any dry plant tissue (Jones and Jacobsen, 2001) but their need is unavoidable.

FUNCTIONS AND UPTAKE FORM OF MICRONUTRIENTS IN PLANTS

The micronutrients generally gets involved in enzymatic and catalytic functions of plant system which holds the key to the important functions like chlorophyll synthesis, respiration processes, ion fixations, transformations etc. The micronutrients in the soils cannot be taken up by the plants in elemental or non-charged form but the plants uptake the micronutrients only in ionic or charged forms (exception of boric acid – it is taken up in uncharged form).

MOBILITY OF PLANT MICRONUTRIENTS

The mobility of nutrients from soil to plant system occurs through active (Carriers concept theory) and passive absorptions (Mass flow, Diffusion and Root interception). Once the plant root absorbs the micronutrients then they easily move from root to the plant system through the xylem. If a deficiency of micronutrient occurs in the plant system then the mobile nutrients will start to move to the deficient place. Thus, the primary knowledge on the mobility of micronutrients will be helpful in finding out the deficiency of micronutrients.

The deficiency symptoms of mobile nutrients will be seen in the lower leaves whereas the deficiency symptoms of immobile nutrients will be seen in the upper leaves. The deficiency symptoms get varied from crop to crop (Havlin et al., 2001).

Table 3. Functions and uptake form of micronutrients in plants

Micronutrient	Functions	Plant nutrient uptake form
Iron (Fe)	Chlorophyll and enzyme synthesis	Fe^{2+}, Fe^{3+}
Zinc (Zn)	Enzymes systems that regulate metabolic activities	Zn^{2+}
Copper (Cu)	Catalyst for respiration	Cu^{2+}
Manganese (Mn)	Controls oxidation-reduction systems	Mn^{2+}
Boron (B)	Sugar translocation and carbohydrate metabolism	H_3BO_3, $H_2BO_3^-$
Molybdenum (Mo)	Nitrogen fixation and transformation	MoO_4^{2-}
Chlorine (Cl)	Oxygen production in photosynthesis	Cl^-
Nickel (Ni)	Seed germination, Urease functioning	Ni^{2+}

The deficiency symptoms of particular nutrients can be reclaimed either by the application of organic or inorganic fertilizers. Organic fertilizers include farmyard manure, green manure, green leaf manures etc. whereas inorganic fertilization includes soil drenching and foliar application of respective micronutrients.

FACTORS AFFECTING THE UPTAKE OF MICRONUTRIENTS IN PLANT

pH	The pH values outside the physiological range damages the plant tissue and carriers inhibit the salt absorption
Light	It indirectly affects the plant functions by altering the stomata opening and closing mechanisms
Interaction	Absorption of one cation/anion gets influenced by the presence of another cation/anion that affects the nutrient absorption
Growth	Increased metabolic activity accompanied with more water uptake enhances salt absorption that influences the vegetative growth of plant

MALNUTRITION

Table 4. Mobility and deficiency symptoms of micronutrients in plants

Micronutrient	*Mobility*	
Iron (Fe)	*Immobile*	*Intervienal chlorosis* *Mottle leaf in sugarcane* *Lime induced chlorosis*
Zinc (Zn)	*Immobile*	*Khaira disease of paddy* *White bud of maize* *Frenching of citrus*
Copper (Cu)	*Immobile*	*Multiple bud formation* *Fruit crack* *Exanthema of fruit tress*
Manganese (Mn)	*Immobile*	*Pahala blight of sugarcane* *Marsh spots of peas* *Speckled yellow of sugarbeet*
Boron (B)	*Immobile*	*Button shedding of coconut* *Hen and chicken in grapes* *Hard fruit of citrus*
Molybdenum (Mo)	*Mobile*	*Whiptail of cauliflower* *Scald of legumes* *Yellow spot of citrus*

According to the spectrum of malnutrition by FAO, it has been observed that, in the developing world, one in five people are chronically undernourished. Nearly 2000 million people were suffering from micronutrient malnutrition whereas hundreds of millions suffer from the diseases that caused due to excessive or unbalanced diet. More than half of the world's disease burden was caused due to malnutrition or excessive nutrition. Women and children were more vulnerable to malnutrition when

compared with men. According to UNICEF, in the global scenario, more than 20 million infants are born weighing less than 2.5 kg each year. The growth of children gets affected so that the problems of underweight and wasting were noted in children. Children of rural areas are more likely to suffer in underweight when comparing with urban children. Malnutrition condemns a child to be weak and girls suffer during pregnancy and child birth.

MICRONUTRIENT CHAIN – SOIL TO HUMAN

For good health, productive and longevity of life a human should be supplied with a balanced diet that meets the nutrient requirement. Lack of micronutrients affects the soil health which in turn affects the plant health that directly reflects on human health. In Indian soil, on an average, 36.5, 12.8, 7.1, 4.2 and 23.2 per cent of soils are deficient in Zn, Fe, Mn, Cu and B, respectively (Shukla et al., 2019). Crops that have been raised in Indian soils show one or more micronutrient deficiencies. Intensively grown crops like cereals, pulses, oilseeds and vegetables show micronutrient deficiency. The marketability value of fruits, vegetables and ornamental crops gets affected due to the symptoms arise from micronutrient deficiency (IZA, 2019). Globally, 2 million people were affected by micronutrient deficiency.

ALLEVIATING MICRONUTRIENT MALNUTRITION

In order to overcome and eradicate the micronutrient malnutrition in the global population, some of the practices like intake of micronutrient supplements, consuming the food in bio-available forms and sticking on to healthy diet plans will be helpful (Narwal et al., 2017).

- Supplementation: In the targeted population, the deficiency of micronutrients can be rectified through the supplements. Supplements are short term and expensive strategy that completely relies on government support and individual obedience.

- Bio-available micronutrients: The increased concentration of micronutrients in the economical parts of plants like seeds, leaves, stem, flowers etc., does not promise that the micronutrients will be bio-available to human. The economical part of the plants can be fortified with micronutrients so that it will remain in bio-available form. Biofortification is a process in which the density of nutrition in the food crops will be increased through good agronomical and breeding practices. In different parts of the world, researches on biofortification of iron in pearl millet, cowpea and Zn biofortification of rice, maize and wheat were under progress.
- Dietary modification: Food selection, preparation and processing patterns should be changed. Indigenous foods with traditional household processing and preparation helps in retaining the bio-available nutrients.

CONCLUSION

Malnutrition is a health peril which all the soil, plant and human face and now micronutrient malnutrition is an emerging risk. In nature, everything has a chain, from single sense to sixth sense; understanding the micronutrient chain, which passes from soil to plant to animal/human, will be helpful in overcoming the soil/plant/human health risk. We, the mankind completely depend on ecology but we often neglect it. All the health risks of human, haves its own remedy in ecology itself. All big things start from small beginnings so it's time for us to hub on unnoticed things of our ecology, a simple care towards ecology will cure our soil, plant and human problems. Thus, focusing on the forms and functions of ecologically important micronutrients will helps us in poignant towards a healthy world.

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