Frank Notes

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Micronutrients in Balanced Plant Nutrition

Seventeen nutrients namely carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S), zinc (Zn), copper (Cu), manganese (Mn), iron (Fe), chlorine (Cl), boron (B), molybdenum (Mo) and nickel (Ni) have been recognized so far essential for plant growth. Out of these, C, H and O, classified as structural elements, constitute approximately 95% of the plant dry matter. Remaining 14 elements classified as major (N, P, K, Ca, Mg, S) and micronutrients (Fe, Mn, Zn, Cu, Ni, B., Mo and Cl) constitute 4.95 and 0.05% of the total dry matter, respectively. Plant requirement for micronutrients compared to macronutrients is 1 million to 1 thousand times less. But these are as essential as are the major nutrients because in absence of 1 Mo atom in plant, 1 million N atoms cannot organize themselves to produce that plant.

Depending on the form in which plants absorb micronutrients, these are further subdivided as cationic (Fe, Mn, Zn, Cu and Ni) and anionic (B, Mo and Cl) micronutrients. Chlorine and Ni don't find significant mention because Cl is more abundant in air and there is a paucity of data on Ni, latest addition to the list of essential nutrients. From practical view point for agriculture, emphasis is on Fe, Mn, Zn, Cu, B and Mo. In general, deficiency of micronutrients causes fall in crop productivity and farm income, because yield-enhancing characters like number of flowers; grain filling; number, shape, size and weight of fruits; and integrity of fruits/ vegetables get adversely affected. Optimum B supply is not only closely related to productivity, but is also crucial for sustaining quality of produce. Small and marginal farmers who primarily earn their livelihood from cultivation of fruits and vegetables are likely to be hit hardest by increasing incidences of micronutrient deficiencies.

Role of iron and zinc in human nutrition has been clearly established during last sixty years or so. World Health Organization has ranked Fe and Zn deficiencies as 5th and 6th among top ten leading causes of illness and diseases in the low income countries. Alarmed at the gravity of situation, Consultative Group for International Agricultural Research (CGIAR) institutes have launched HarvestPlus programme on biofortification of major crops with Zn and Fe. Some zinc-fortified rice varieties have already been released for cultivation.

Global study made for FAO in 1982 showed that the deficiency of Zn and B could be suspected in almost every country and India is no exception. As per analysis of over 200,000 soil samples collected using global positioning system (GPS) during 2011-17, 36.5 and 23.2% of Indian soils suffer from Zn and B deficiencies, respectively. These figures might further escalate to 51.2 and 44.7%, respectively if soils under marginal deficiencies are brought under intensive cultivation. Iron, Mn and Cu deficiencies are prevalent in 12.8, 7.1 and 4.2% soils, respectively. Fast increasing incidence of Mn deficiency, particularly in coarse textured low organic matter soils of rice-based cropping systems is a matter of concern.

In soils, micronutrients are distributed in five pools namely, water soluble (soil solution); exchangeable; adsorbed, complexed and chelated; associated with secondary minerals and as sparingly soluble oxides; and constituents of primary minerals. Theoretically, total micronutrient content of the Indian soils is enough to sustain and supply them to crops for a period varying from a few hundred to thousand years. Yet their deficiency continues to emerge menacingly because only first three pools of micronutrients (constituting only 2-5% of the total content), are in a state of dynamic equilibrium and supply these nutrients to plants. Hostile environmental and unfavourable soil conditions further affect the micronutrient availability. For example, plant requirement of Fe is only one-trillionth of that present in the soil, yet occurrence of iron deficiency chlorosis is a common feature under high pH, calcareousness, low soil organic matter, poor water quality etc. Situation is further exacerbated with focus of micronutrient nutrition shifting from 'overcoming micronutrient deficiencies in plants and sustaining crop yields' to 'producing micronutrient-dense grains to combat malnutrition in humans'. Unless corrective measures are taken, cultivation of the micronutrient-accumulating crops and crop cultivars without supplementation of these nutrients will further accentuate the onset of deficiencies.

Impressive strides were made in India to combat micronutrient deficiencies in general and zinc in particular. Drop in Zn deficiency from nearly 50% to 36.5% in last 15 years has given good economic returns. Application of zinc alone yielded a produce of nearly 25 million tonnes (Mt) valued at more than 4 billion US dollars. Crop response studies in India on micronutrients

have all along been conducted on 4R principles. Voluminous data of over fifty years' experimentation have yielded best management practices of micronutrient application. Basal soil applications of Zn, B and Cu excel over foliar sprays. Application of 5-10 kg Zn/ha as zinc sulphate and 0.5-1.5 kg B/ha as borax meets the requirements of the whole cropping sequence. Foliar sprays of iron and manganese through the respective sulphates are superior to their soil application. Cost-effective options like seed treatment with Mo, and dipping of rice seedlings before transplanting and soaking of potato tubers prior to sowing in ZnO suspension are also promising techniques. Supplementing soil application of 5 kg Zn/ha with two foliar sprays of 0.5% zinc sulphate one each at earing and milk stage has been found to produce the Zn-rich wheat grains without any yield decrements.

Micronutrient requirements of the crops are relatively small. Crops and crop cultivars grown on the same soil exhibit differential genotypic variability with respect to their micronutrient content/ ability to withstand the deficiency stress. Since total soil micronutrient content *per se* is sufficient, it may sustain higher yield of the cultivars which are capable of mobilizing these nutrients from difficultly available pools. Investigations on isolation of micronutrient-efficient landraces and established varieties present a vast scope on minimizing fertiliser use and maximizing potential on containing micronutrient malnutrition.

Abysmally low use efficiency of micronutrients at 2 to 5% even under the best management practices continues to be a cause of concern and enhancing it constitutes a priority area of research. Although number of products are listed in the Fertiliser (Control) Order 1985, sulphates of Zn, Fe, Cu and Mn are synonymous with micronutrient fertilisers. Borax is a major B-containing fertiliser. Chelated sources per unit of micronutrient are

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two to five times more effective agronomically for crops than the inorganic sources, but the chelate cost per unit of micronutrients is five to 100 times higher.

The uniform application of micronutrient fertilizers in field is a major challenge as these are applied in small quantities. The use of fertilizers fortified with Zn (*e.g.*, zincated urea, zincated DAP, zincated SSP) and B (*e.g.*, boronated SSP, boronated DAP, boronated NPK) and customised fertilisers can address this problem by facilitating the uniform application of small amounts of micronutrients in these fertilisers. Development of micronutrient-containing nanoclay polymer composite (NCPC) smart systems capable of supplying these nutrients synchronous with plant needs offers an exciting field of research. Exploration and evaluation of nano zinc oxide as a future Zn fertiliser is being viewed with skepticism though claims in some quarters are being made of achieving more than 50% zinc use efficiency through use of nano Zn fertiliser.

There has been good growth in consumption of micronutrients particularly in last 10 years. However, there exists a vast gap between application and requirement. The current annual consumption of about 180 thousand tonnes of zinc sulphate is much less compared to projected $ZnSO_4$ requirement ranging between 0.3 to 1.5 Mt for 2025. The situation in case of boron and iron, the 2nd and 3rd most limiting micronutrients, is even worse. The prevailing gap between the requirement and actual use of micronutrients will aggravate the problem of micronutrient deficiencies.

Government is aware of the problem and has taken some initiatives recently to promote the use of micronutrients. However, these policy initiatives are yet to yield the desired results on the ground. Despite the policy of encouraging production of fertilisers fortified / coated with micronutrients, production has not picked up as manufacturers do not find it commercially viable. It is high time to review the policy of fortified / coated fertilisers. The policy should at least allow the recovery of cost incurred on micronutrients and coating / fortification. The rate of customs duty and GST on micronutrients is higher *vis-à-vis* conventional fertilisers resulting in higher farmers' price. All fertilisers listed in Fertiliser (Control) Order, 1985 should be treated at par in terms of customs duty and GST.

The awareness of farmers about the importance and need of micronutrients in improving crop productivity is very limited. The state governments and major fertiliser companies can play an important role in knowledge dissemination. Right from the beginning, FAI has been promoting balanced use of fertilisers including micronutrients. FAI has instituted two annual awards to recognise the outstanding work done by the scientists and fertiliser industry in the field of micronutrients. It has also started bringing out annual publication 'Specialty Fertiliser and Micronutrient Statistics'.

This special issue on Micronutrients is another initiative of FAI to highlight the importance and need of micronutrients in improving crop yields and human health. The special issue includes six lead papers covering important aspects of micronutrients. We hope that all those concerned with agriculture including scientists, policymakers, extension workers and farmers will find the content of the special issue relevant and useful.■