Role of Sulphur, Boron and Zinc Nutrition in Field Crops and Their Status in Eastern Sub- Himalayan Plains of India

Saikat Mookherjee1* & Biplab Mitra2
1Assistant Director of Farms
RRS (OAZ), Uttar Banga Krishi Viswavidyalaya, Majhian, W.B, India-733 133
2Assistant Professor in Agronomy
Uttar Banga Krishi Viswavidyalaya, Pundibari, W.B, India-736 165

Abstract: Apart from N-P-K, Sulphur (S), Boron (B) and Zinc (Zn) play an important role in agricultural crop production system. The deficiency of these nutrients in to the soil is to be addressed seriously and measures are to be taken accordingly to save our crop under sustainable system of production under sub-Himalayan plains of eastern India.

Key words: Boron, deficiency symptoms, plant nutrition, soil fertility, sulphur, zinc

Introduction:
The removal of nutrients with the harvest is a natural process, it can’t be avoided. Higher yield results greater the removal. In addition to the removal of nutrients by various processes like volatilization, fixation, run-off, leaching, erosion as well as harvest of the produce; attention must be paid in to the nutrient balance in soil and adequate nutrient supply to the plants for proper nutrition. Besides replenishing the amount of nutrient taken up by crops, appropriate soil fertility management need to take into account considering the interaction effect among various nutrients present in the soil, the soil-plant-water relationship, crop sequence, cultivation practices, land management system and agro-ecological conditions.

The sub-Himalayan plains popularly known as terai zone, in West Bengal, an eastern state if India is experiencing a typical sub-tropical pre-humid climate with high annual rainfall. The soils are formed by alluvial deposits of different river system, e.g. Teesta, torsa, Mansai, Kaljani, Raidak, Sankosh and Gadadhar. The depth of the soil ranges from 0.15 to 1.00 m. Though the soils are acidic with poor fertility status, N, P and K fertilization is in almost balanced (2:1:1) in the terai zone as well as in the state of West Bengal and although no problem of deficiency of Ca and Mg have been strikingly observed, responses to Ca and Mg fertilization in rabi and plantation crops have been reported in low CEC soils of terai zone. Significant higher yield of lentil and boro paddy with application of dolomite and organic manure have been observed in terai zone of West Bengal.

Sulphur (S) is now recognized as the fourth major element after N, P, K and its deficiency is reported to be wide spread in many parts of State of West Bengal as well as many blocks of Jalpaiguri, Cooch Behar and Alipurduar district of terai zone. On the other hand wide-spread deficiency of Boron (B) & Zinc (Zn) and their economic response to crops have been reported by many workers at eastern Indian terai zone also as these nutrients might have a great role in crop production.

Keeping these in mind, an attempt has been made in this article to highlight how S, B and Zn take major role in soil fertility and crop response. The Block-wise fertility status in relation to S, B & Zn of the major area of terai zone of sub-Himalayan plains at eastern India comprising blocks of Cooch Behar, Jalpaiguri and Alipurduar district are presented here for better understanding of the actual scenario.

Role of Sulphur (S) nutrition:
S is an essential plant nutrient for crop production. For oilseed crops, S containing fertilizers are especially important because it require more sulphur than cereal crops or pulses. The average quantity of S required to produce one ton of seed is about 4 kg for cereals; 9 kg S for legume crops; and 12 kg S for oil crops. In general, oil crops require about the same amount of S as, or some times more than phosphorus for high yield and production quality. In intensive cropping including oilseeds, S uptake by the plants can be very high and practice of removal of crop residue from the field along with the produce is common. This lead to considerable S depletion in soil if the corresponding amount of S is not applied through
fertilizers or other source of plant nutrients. The importance of sulphur in agriculture is being increasingly emphasized and its role in crop production is well recognized [1], [2] and [3]. S is best known for its role in the formation of amino acids methionine (21% S) and cysteine (27% S); synthesis of proteins and chlorophyll; oil content of the seeds and nutritive quality of forages [4]. It also serves important structural, regulatory and catalytic functions in the context of proteins, and as a major cellular redox buffer in the form of the tripeptide glutathione and certain proteins such as thioredoxin, glutaredoxin and protein disulfide isomerase. Although S is one of the essential nutrients for plant growth with crop requirement similar to phosphorus, this element was neglected for many years, because fertilizers and atmospheric inputs are being supplied the soil with an amounts of S. But these are becoming a blanket application. Now, areas of S deficiency are resulting widespread throughout the world due to the blanket use of high-analysis fertilizer with low S content, low S returns with farmyard manure, use of high yielding varieties in intensive agriculture, declining use of S containing fungicides and reduced atmospheric inputs caused by stricter emission regulations. An insufficient S supply can affect productivity and quality of the field crops.

Sulphur deficiency symptoms in crops:

Cereals:
Rice: Reduced plant height and tiller number; the whole plant may look chlorotic at tillering stage in case of severe deficiency. Leaf blade becomes pale yellowish at the initial stage.
Wheat: Yellowness of leaves observed which is generally prominent between the veins. Younger leaves become yellowish but older leaves remain green.
Maize: Yellowning between the veins along the length in seen particularly in upper younger leaves.

Oil Seeds:
Rapeseed Mustard: Reddening of the underside of leaves and stem is observed. Cupped leaves may form flowers. Flowers abort prematurely resulting in poor pod formation. Sulphur deficiency reduces oil content in seeds.
Ground Nut: Young plants are smaller than normal, pale and more erect from the petiole than normal plants giving the trifoliate leaves a “V” shaped appearance. In new leaves area around the main vein become pale. Nodulation and pod formation is restricted.
Linseed: Yellowning, Curling and premature drying of tips of young terminal leaves is evident number of floral bud reduce and most of these fail to open.

Sesame: The young leaves turn pale green and then turn golden yellow. Restricted growth, lesser number of flowers, pods and seed yield reduce.

Pulses:
Black gram: chlorosis starts from the tip of the young leaves and spread along the margin. Young leaves that emerge after onset of sulphur deficiency are yellow.
Green gram: stunted growth, poor branching. Flowers are reduced in size and pods have shrunken seeds.
Pigeon pea: upper young and middle leaves turn yellow, leaf size reduced and flowering suppressed. Flowers lack normal yellow colour and shed early. Retarded seed development.

Role of Boron (B) nutrition:

The abundance of boron in the universe is extremely low and it is never found in its elemental form in nature, but is found in rocks and concentrated in deposits as borates, i.e. bound to oxygen together with sodium, calcium, silicon, or magnesium, and it will usually be hydrated [5]. At least 200 minerals are known to contain the element boron; however, only four boron-containing minerals, borax i.e. hydrated sodium borate, kernite: it is the form of hydrated sodium borate, colemite: it is the hydrated calcium borate hydroxide, and ulexite is the hydrated sodium calcium borate hydroxide are of commercial importance [6]. Most during rock weathering, boron goes easily into soil solution mainly as boric acid [7] and is readily available for plant uptake, but this pool constitutes about 10% of total soil boron [8]. Boron availability in soil can be affected by several soil factors such as pH, texture, temperature and by organic matter [9], soil pH being one of the most important parameters.

The primary role of boron is in calcium metabolism and appears to be concerned to keep Ca in soluble form and increases its mobility in plants. Besides its role in nitrogen absorption it efficiently acts as a regulator of K-Ca ratio in plants. When plants grow in media with enough boron availability, xylem loading of boron is performed both by boron diffusion across lipid bilayer and facilitated permeation via protein channel [10]. Nevertheless, an active transport system mediated by BOR transporters is mainly responsible for export boron towards xylem under boron-deficient conditions. In neutral or slightly acid soils of terai zone, boron occurs mainly as dissociated boric acid, and in this form is absorbed by plant roots [11] and [8], which is mobile and easily lost by leaching under high rainfall
conditions leading to boron deficiency in plants that grow there.

Boron deficiency symptoms in crops:

Cereals:
Rice: emerging leaves become white and rolled. Delayed maturity and caused sterility. Wheat: dead growing points distorted blossom development. Seed formation affected.

Oilseeds:
Rapeseed and Mustard: Restricted growth, epical bud dries up, pod formation affected, seed size is also decreases. Ground Nut: Chlorosis and browning of leaves occur. The seeds become black and small in size.

Role of Zinc (Zn) nutrition:

The essentiality of Zn in plants was first shown in maize crop [12], and subsequently in barley and dwarf sunflower [13]. Early reports of severe Zn deficiency symptoms included impaired stem elongation in tomato [14]. Incipient Zn deficiency symptoms in tomato, remedied by resupply of Zn, included reduced protein and starch synthesis whilst sugar content was unaffected [15]. Zinc is the most common crop micronutrient found deficient in the *terai* foothills of Himalaya. Notably, 50% of cultivated soils in India, 30% third of cultivated soils in China, and most soils in Western Australia are classed as Zn-deficient.

Oxidation-reduction reaction in formation of chlorophyll is controlled by several enzymes. Zinc is the main constituent of those enzyme systems which regulates the oxidation-reduction reaction and various other metabolic reactions in plants. It influences the process for formation of some growth hormones in plants and thus helpful in reproduction of plants. It is very much associated with water uptake and water reaction in plant body.

Zinc deficiency symptoms in crops:

Cereals:
Rice: brown off white spot appear usually on third leaf. Gradually it coalesces and entire leaf turns blackish brown. Growth of the plant is affected. In case of severe deficiency all the leaves of the plant become blackish or grayish. Grain filling particularly in hybrid rice is largely affected. Wheat: stunted growth, interveinal chlorosis appears. Seed yield is affected. Maize: White band beginning at the base of the leaves and extending towards the tip. Upper leaves of the plants mostly affected. Short internodes and stunted appearance.

Status of S, B and Zn in sub-Himalayan plains:

Though most of the districts fall under this region of sub-Himalayan plains are non-deficient in S, but an appreciable area falls under threat and likely to be deficient in some blocks of Jalpaiguri district (Fig.1). Except some small pockets, the *terai* soils are highly deficient in B. Out of the entire zone; Kalchini and Kumargram block in Alipurduar district are showing non-deficient to likely to turn deficient status (Fig.2). Zn status shows an erratic distribution with regard to over the entire zone with deficient status over many of the pockets in Jalpaiguri and Alipurduar district and many pockets in Cooch Behar district is likely to deficient status (Fig.3). It’s the right time for the farmers of this region to take appropriate measures against these crucial nutrient deficiencies in order to save a great loss in future.
Fig. 2: Block wise soil status of Boron. A. Cooch Behar district and B. Jalpaiguri and Alipurduar district.

Legend:
- Deficient
- Likely to turn deficient
- Non-deficient

Fig. 3: Block wise soil status of Zinc. A. Cooch Behar district and B. Jalpaiguri and Alipurduar district.

Legend:
- Deficient
- Likely to turn deficient
- Non-deficient

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<th>Districts</th>
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Ameliorative measures against deficiencies of S, B and Zn:

Before taking any corrective measures against any nutrient deficiency in a particular field, the following approaches are very important.

*Develop a sharp eye:* Deficiency symptoms on foliage or stem have to be recognized well at its first instances so that proper measures can be taken accordingly.

*Soil test values:* A soil test value will provide a general indication of micronutrient which would be a good basis for diagnosis.

*Plant analysis:* A plant analysis or tissue test is regarded as one of the accurate means of deficiency. This is very useful if it is combined with soil test values.

*Review field history:* A detailed field history or fertility map for every individual farmers will be helpful for determining such deficiencies.

After proper investigation in a specific site if it is found that the soils are deficient in any of these
nutrient elements, the following measures can be taken up.

**Against S-deficiency:**  
- Soil application of elemental -S @20-40 ha⁻¹.  
- More use of fertilizers containing S viz. SSP (12.5% S), ammonium sulphate (24.2% S), zinc sulphate (17.8% S) etc.  
- Proper decomposition of plant residues helps in riding back S in soil.

**Against B-deficiency:**  
- Soil application of borax @10-15kg ha⁻¹.  
- Foliar application of borax @ 0.25-0.50%- 1 or 2 spraying before flowering depending on severity.  
- Seed treatment with borax- seed soaking in 1% borax solution for 2 hrs.

**Against Zn-deficiency:**  
- Soil application of ZnSO₄ @ 20-25 kg ha⁻¹ during final land preparation.  
- Foliar application of Zn SO₄ @ .050% + lime @.025%- 1 or 2 spray depending on the extent of deficiency.  
- Root dipping in 2% ZnO solution for few minutes.  
-Genetic improvement on crop yields on zinc deficient soils by exploiting genotypic differences in Zn uptake and tissue-use-efficiency that exists within crop species.

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**References:**


