Essentiality of micronutrients in soil -A Review

Abstract

Micronutrients are very abundant in soil but plants normallyabsorb only a little amount of them, giving them the name "trace elements". Boron (B), Copper (Cu), Iron (Fe), Manganese (Mn), Zinc (Zn), Molybdenum (Mo), and Nickel (Ni) are the essential micronutrients that are required in smaller amounts but crucial for plant growth and development. Besides providing essentiality in fruits and seeds formation, they are helpful in performing various metabolic processes, nutritional management, reproductive growth, chlorophyll synthesis, and other key plant activities.Among all the essential micronutrients, two particular elements, zinc (Zn) and boron (B) are deficit in acidic soils and zinc (Zn) and iron (Fe)are insufficient in semi-arid soils, which have become a rising problem in a variety of cropping systems thereby,raising alarms for the future. Our understanding of difficulties relating to micronutrients might be improved by the production of detailed soil micronutrient maps that cover wide geographic regions, making relevant judgments about the delivery and distribution of fertilizers supplemented with micronutrients to areas that are deficient in these particular micronutrients. The outcomes of these delineation efforts would also be very helpful in developing site-specific suggestions to increase the micronutrient content of food crops. It's important to note that soil micronutrient availability directly affects plant growth.

Keywords- Micronutrients, Soil, Sustainability, Quality Production

Introduction

Agricultural sector is regarded as the backbone of any country governingits social as well as economic status. As per the reports, World's population is projected to rise about 9.6 billion people by 2050 and in order to feed such outnumbered population the agricultural and horticultural production levels must increase by 70 per cent (Shubham *et al.*, 2022). Life would not be easier without agriculture as healthy and nutritious food is of utmost importance to sustain lives on earth. In present, unbiased application of major fertilizers *i.e.,*NPK without any micronutrient sources to crops have become an alarming issue in order to equilibrate the people demand for nutritious food and to achieve sustainable agricultural goal. Therefore, integration of macro and micro nutrients is the only alternate to sustain soil fertility levels and in addition to boost the productivity scales. Expectancy of improved cultivars and increased pressure on land for higher production per area significantly reduced the trace elements in soils a well as in grains (Cakmak.,2012) Moreover, it has been found that deficiency of trace elements has a pronounced effect on food safety and nutritional security (Meenakshi,.2010; Ghaly.,2010; Zadeh.,2011; Shubham *et al.,* 2023).Other micronutrients should also be provided in adequate amounts in order to overcome the losses caused due to lack of these nutrients (B,Zn, Fe,Cu,Mn,Ni,Cl,Mo). Quality of produce is the major concern with respect to micronutrients as deficiency of any nutrient can lead to issues like 'HIDDEN HUNGER'and will adversely affect the humans as well as animals' life. Some unhoped problems like 'malnutrition' can be occurred due to the consumption of micronutrient deficient foods.Accordingto reports, it has been found that 5.4 per cent of Indian soils are copper deficit and therefore responsible for retarding the growth and development in various crops (Shukla *et al.*, 2014). Application of copper artificially on foliar parts have been found to increase the yield and grain quality in rice crop(Silviya., 2017).In okra, many parameters like plant height, chlorophyll content was significantly increasedupon the artificial zinc application (Lata *et al*., 2018). Applying these micronutrients manually has showed useful effects like foliar application of iron has enhanced the fruit yield which consequently, increased the market value of tomato (Denden *et al.*, 2016).As per the criteria of essentiality we have 17 micronutrients, all of them plays a vital role in growth of plant. if any of these nutrients are not present in the soil, yields will not be as per the expectation of the grower, and which effects the agriculture product quality. According to Arnon and Stout, Cu is necessary for the development of plants, it has a crucial role among the micronutrients, it has significantly contributedin crop growth by enhancing the pollen viability and tillering of harvest (Das.,2014) Several proteins and enzymes,including plastocyanin, diamine oxidase, and ascorbate oxidases, are present in copper. These enzymes are essential for photosynthesis, respiration, and the production of lignin. It serves as a structural component in regulatory proteins and is involved in hormone signaling, photosynthesis, mitochondrial respiration, stress responses, and cell wall metabolism. After several years of cropping system, nutrients have been continuously used by from the soil and thereby, fertility of soil has been reduced in certain places. This regular and continuous depletion of nutrients in soil can be overcome by applying the crop residue.

There is enormous need to understand the level of deficiency of micronutrient as distribution of these micronutrients in soils are highly related to each other. Some elements have connections to their parent materials, and these connections may endure in soils. The amount of a soil nutrient that is available to plant roots during some beneficial time, such as a growth season, is known as availability (Welch.,1991). Micronutrients are immediately absorbed by plant roots from the soil solution.

Micronutrients significance in agricultural production

As majority of micronutrients serves as a co-factor for various enzymes, so they increase quality and yield and performs various activities in the plats such as protein metabolism, metabolism of carbohydrates, photosynthetic rate etc., hence the amount of protein will rise, TSS and other quality parameters will get improved. They also alter the effect of N2-fixation in legumes as micronutrients like Fe and Mo are two important constituents of nitrogenous enzymes which helps in the formation of 02 scavenger(Rahman *et al.*,2020).

Avoiding the provision of surplusnumberof macronutrients in soil can leads to improvement in an efficiency and utilisation of the micronutrient.

Factors effecting micronutrient availability

1.Soil pH

Various parameters like solubility, concentration in soil solution, mobility of micronutrients in soil, and the way how plants utilize these micronutrients, all depends on the pH of the soil. Any rise or increase in the pH level tends to decrease the availability of B, Zn, Cu, Fe, Mn, Ni, Cl, Mo tends to decrease in soil. Sesquioxide soil surface usually absorbs these nutrients. The only micronutrient which exists in solution as non-ionised molecule is Boron(Shukla*et al.*,2014) .

2.Organic Matter

It can be categorised as water soluble and water insoluble compounds. Water soluble compounds are humic acids or humin compounds whereas water insoluble are fulvic acids. Many anionic organic groups are contained in humic acids such as carboxyl, hydroxyl, and phenolic which interact with metal cations. When humic acids and metals come in contact, then complexation reactions are most common(Shukla *et al*.,2014).

3.Temperature

Temperature plays a vital role in micronutrient availability; Micronutrient availability tends to decrease with low temperature as root activity and microbial activity also get reduced to some extent. Mobilisation and Immobilisation reactions easily get decrease or increase the level of organically bound Cu and it’s utilisation by plants(Moraghan and

Mascagni.,1991).Root growth and metabolic activity also starting decreasing when the temperature is low which consequently, increase the bicarbonate level and increase the chances of deficiency of Iron with increase solubility of Co2 in soil.

4.Moisture

Decrease in moisture content, tends to immobilized the colloidal particles. Consequently, absorption of micronutrient occurs on soil surface, but when moisture content decreases, leaching occurs. Excessive soil moisture leads to restriction in the diffusion of O2 in soil, which leads to reduction in Mn (Manganese) content(Shukla*et al*.,2014).

Importance and deficiency symptoms of micro-nutrients

1.Zinc

Zinc is required primarily by western crops;it is necessary for citrus crops to give foliar treatment of zinc once or more time a year. Zinc is a divalent cation and it does not go any valence change and consequently, no redox activity takes place. In addition to serve as a functional structure and regulatory co-factor of several enzymes, zinc acts as metal component of enzymes. It has been reported that there are more than 80 zinc-containing proteins. Protein content of zinc-deficient plants and their rate of photosynthesis is getting reduced rapidly. RNA polymerase requires zinc to function, and if the zinc is taken away, the enzyme is inactivated. Additionally, zinc is necessary for the structural integrity of ribosomes. The drop in protein concentration of Plants lacking in zinc are also a result of increased RNA degradation rates. Higher RNase activity rates are a common characteristic of Lack of zinc (Rehm.,2010).Application of phosphorus fertilizers in large extent to soils which are having less zinc can lead to zinc deficiency and increase the zinc requirement of the plant. Induced deficiencies in plants can result from various factors, including the inhibition of zinc uptake by other divalent cations or a dilution of plant zinc due to increased growth resulting from additional phosphorus. Soil chemical processes can lead to increased zinc adsorption to hydroxides and oxides of iron and aluminium, as well as to CaCO3.Several experimental findings suggest that there are further interactions between phosphorus and zinc in plants(Shukla*et al*.,2014; Shubham *et al.,* 2022). These interactions encompass the inhibition of zinc translocation from the roots to the shoot and a phenomenon termed "physiological inactivation" of zinc within the shoots. Notably, the symptoms of zinc deficiency seem to be linked more to the phosphorus/zinc ratio than to the actual zinc concentration in the shoots.The results of the study amply supported a link between zinc shortage and adverse effects on okra plants, particularly when considering the impact of different zinc treatment rates. The results showed that applying 7.5 kg of zinc per hectare as opposed to 5.0 kg of zinc per hectare significantly improved different okra growth metrics, as shown in Table-1

Table-1. Importance and deficiency symptoms of micro-nutrients

S.No	Characters	Zinclevels(kg/ha)				
		Control	2.5kg Zn(Zn1)	5.0kgZn(Zn2)	7.5kgZn(Zn3)	CD (P=0. 05)
1	Plantheight(cm) at45DAS	87.29	89.05	92.09	95.46	5.29
2	Plantheightath arvest(cm)	102.57	105.05	113.09	118.23	6.46
3	Leafarea(cm2)	98.31	105.77	113.97	116.80	5.04
4	No.ofbranches	2.31	2.36	2.50	2.58	0.10
5	Chlorophyllc ontent(mg/g)	1.40	1.48	1.53	1.60	0.09
6	Fruitlength (cm)	8.15	10.05	11.13	11.70	0.42
7	No. offruit/pla nt	19.35	20.91	21.90	22.33	1.23
8	Fruityield/plant (g)	60.07	187.40	224.84	233.67	10.30
9	Fruit yield/plot (kg)	1.44	4.50	5.40	5.61	0.25
10	Fruit yield/ha (q)	33.37	104.11	124.91	129.81	5.72

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Zinc Deficiency Symptoms

- Reduced stem length, shorter internodes, the creation of terminal leaf rosettes, and a decrease in the development of fruit buds are all signs of zinc deficiency in plants.
- Interveinal chlorosis can give leaves a mottled look, and anthocyanin-induced red spot-like discolorations might occasionally arise. It's important to remember that signs of phosphorus toxicity, such as chlorosis and necrosis on older leaves, are probably the cause of zinc deficiency in plants.
- Also, possible after the first year are dieback of twigs and striping or banding patterns on maize leaves (Jain.,2007).

2.Iron

Iron is helpful in plant growth as it helps plants by promoting chlorophyll production and serving as a catalyst for critical biochemical processes including respiration, photosynthesis, and the symbiotic nitrogen fixation process. (Reddy.,2004). High level of manganese and or high lime content in soil can induce iron deficiency in soils. Plants take up Iron as ferrous or ferric ions, Iron in plants is stored up in the form of ferratin, Iron's capacity to change between two oxidation states in solution is essential to its function in plants. Iron is stored in plants as a protein called ferritin. Iron is mostly present in soils under aerobic conditions as insoluble oxides and hydroxides, frequently associated to organic chelates. Because of this, many soils have very low levels of free iron in the soil solution. In order to mobilize and make iron accessible for root absorption, plants have created mechanisms(Shukla *et al*,.2014).A few of these systems are not just for absorbing iron. By excreting protons that lower the pH in the rhizosphere, roots play a crucial part. Iron is more soluble and accessible when the pH is lower. Furthermore, roots discharge organic acids into the soil, which serves two purposes. Firstly, it lowers the external pH and secondly, these acids can combine with iron to create soluble complexes. Numerous crops, including maize, sorghum, particular soybean cultivars, turfgrass, as well as particular kinds of tree crops and ornamental plants, are regularly impacted by iron shortage (Cannolly.,2002).

Iron Deficiency Symptoms

- Young leaves may exhibit interveinal chlorosis as a symptom, however less severe cases may result in the veins losing their green color entirely. Additionally, twig dieback may occur, and in the most extreme situations, the ailment may result in the loss of all limbs or possibly the whole plant (Jain.,2007).
- Numerous studies have shown that iron has beneficial effects on fruit weight. The foliar application of iron has been shown to significantly improve the average fruit weight for strawberries and lemon trees, as well as to increase the number of fruits and production per tree. Similar beneficial results were seen with pomegranates(Shukla*et al*.,2014).
- According to our research, 1000 ppm of iron is the ideal level for tomato production, especially in terms of medium and big fruit output(Shukla*et al*.,2014).

3.Manganese

As an enzyme activator for growth-related enzymes, manganese is essential. Along with iron, it also aids in the synthesis of chlorophyll and takes part in the splitting of water, which releases oxygen gas(Shukla *et al*.,2014).The oxidation reaction $2H_20$ O_2 + 4 H+ + 4 e- represents the water splitting reaction. Superoxide dismutase, a protein that also contains manganese, is an essential protein. This enzyme prevents the production of potentially hazardous oxygen radicals when O_2 receives one electron and is broadly distributed in aerobic species. This extremely dangerous free radical is changed into hydrogen peroxide (H_2O_2) by superoxide dismutases, which is then broken down into water (Millaleo.,2010).It's important to remember that an excessive manganese content may cause an iron deficit. Plants typically absorb manganese in the form of Mn^{++}. Manganese is frequently needed together with zinc when spraying citrus leaves. Although manganese deficiency may be seen in some tree crops, this element is not always required. An increasing body of research, however, points to the possibility that manganese supplementation might increase the production of glyphosate-resistant soybeans(Shukla*et al*.,2014).

Manganese Deficiency Symptoms

- Young leaves with interveinal chlorosis, where the green hue progressively changes to a darker tone along the veins, are one of the symptoms of this ailment.
- There is no clear distinction between the veins and the interveinal spaces, unlike iron insufficiency. You could see interveinal brown spots and streaks in barley, interveinal

white streaks in wheat, or gray specks in oats, depending on the particular crop (Jain.,2007).

- Data from two experimental seasons are shown in Table 2 on the effects of different treatments on parameters like fruit set (%), fruit weight (g), and yield (kg). The results unambiguously shows that the use of zinc and manganese spray considerably boosted fruit set in both seasons when compared to the control group(Shukla*et al.*,2014).
- Furthermore, compared to other treatments, the combination of zinc at 3% and manganese at 60 mg/L produced the greatest fruit set percentages, which were 49.34% and 50.69% for the two seasons, respectively.
- This result might be explained by the fact that micronutrient components are necessary in only modest amounts for healthy plant development and fruit production(Shukla *et al.*,2014).
- The data also show that the control treatment produced the fruits with the largest weight. This is likely because these components increased the number of flawless blooms, which improved fruit set and increased the quantity of fruits, which in turn increased competition for nutrients.
- Additionally, both experimental seasons' yields (kg) increased thanks to the addition of zinc and manganese, with the largest yield achieved when spraying zinc at 3% combined with manganese at 60 mg/L.

Table2. Effect of sprayingMnandZnon fruitsetandyieldofpomegranatetrees

Zn(%)	Mn(mg/l)	Fruitset(%)	Yield(kg)
0	0	43.25	23.56
	20	45.19	23.63
	40	45.47	23.81
	60	46.08	23.98
1.5	0	43.87	24.59
	20	45.89	24.95
	40	47.11	25.07

	60	48.80	25.40
3	0	46.34	25.71
	20	48.00	25.97
	40	49.45	26.56
	60	50.55	26.77
CD (0.05)		2.94	2.40

(Shukla*et al.*,2014)

4. Copper

Plants have complexed forms of copper. An overabundance of copper is attached to phytochelatins, which might be thought of as "plant claws," and sulfur-containing peptides, similar to other potentially dangerous heavy metals. Copper is found in solution as the ions cuprous (Cu^{+}) and cupric (Cu^{++}). The majority of cuprous copper is found in complexed forms because cuprous copper easily oxidizes to cupric form. While cupric complexes sometimes have blue or brown hues, these cuprous complexes are normally colorless(Shukla*et al.*,2014). Copper plays a critical role in electron transport and the capturing of energy through oxidative proteins and enzymes, acting as an activator for several enzyme systems in plants. It could also help produce vitamin A (Rehm., 2009). The synthesis of proteins can be hampered by copper deficiency. Although it's uncommon to consider the native copper supply as needing supplementing, some tree crops grown in sandy or organic soils may benefit from more copper. It's vital to remember that copper can be poisonous at low doses, thus before using it, a solid need for supplementing should be established. Different plant species might exhibit a wide range of deficiencies.

Copper Deficiency Symptoms

- A leaf may exhibit chlorosis (yellowing) or take on a strong blue-green hue with curled edges as one of the symptoms. The bark of trees is frequently rough and blistered, with gum leaking from the cracks.
- Young shoots might undergo dieback, and in annual plants, fruiting and blooming could be hampered, which could cause seedling demise. In oranges, gum pockets may develop around the center pith, slowing growth overall(Jain.,2007).

5.Boron

By altering the development of meristem cells, boron has a significant impact on the function of plants. Although its main purpose is often connected to the composition of the cell wall and other chemicals, it also performs crucial functions in the transfer of sugar and the germination of pollen grains. The main form of boron present in soil solutions with a pH lower than 8 is undissociated boric acid ($B(OH)^3$), which is the main form absorbed by plant roots. Only at higher pH levels does it dissolve into $B(OH)^4$- (Gupta.,1993).

Boron Deficiency Symptoms

- Nutritional deficiencies in plants are a common problem. Boron is prone to leaching from soils in the form of $B(OH)^3$ in areas with a lot of rainfall. As soil pH rises, the availability of boron decreases, notably in calcareous and clay-rich soils.
- Additionally, availability is drastically reduced during droughts, most likely as a result of reduced boron mobility to the roots and boric acid polymerization. The youngest leaves or terminal buds of the shoot will show signs of boron shortage by becoming discolored and maybe withering(Shukla*et al*.,2014).
- Shorter internodes caused by this deficit give the plants a compact or rosette-like look. Typically, the youngest plant tissues are most commonly impacted by the deficit. Additionally, interveinal chlorosis and bent leaf blades are possible characteristics of mature leaves.
- A bud, bloom, and developing fruit drop is a recognizable indication of boron deficiency.Although cells may continue to proliferate in situations of boron shortage, the structural elements are not fully differentiated. Additionally, it appears that boron influences how plants use their carbohydrates. Because boron is immobile in plants, it is important to have a steady supply at all stages of development.

6.Chlorine

A strange mineral nutrient is chlorine. Its normal concentration in plants is similar to a macronutrient, while its importance for growth is closer to a micronutrient. The ionic form of chlorine, chloride ions (Cl^-), may be found in aqueous solutions and is extensively dispersed in nature.According to research, chlorine is quite mobile and principally responsible for charge compensation and osmoregulation in higher plants. Since plants normally obtain chlorine from a variety of sources, including soil reserves, rainfall, fertilizers, and air pollution, possible dangerous amounts rather than a lack are of more concern(Shukla *et al*.,2014). However, there have been a few cases where the use of chloride as a fertilizer has benefited the development of wheat.

Chlorine Deficiency Symptoms

- Young leaves start to turn a bright blue-green color, which is followed by withering and chlorosis as symptoms.
- Along with a bronzing appearance on the leaves, excessive lateral root growth is also seen. Tomatoes and barley can also develop chlorosis and necrosis (Jain.,2007).

7.Molybdenum

Although molybdenum is classified as a metal, it primarily exists in aqueous solutions as the molybdate anion. Molybdate appears to be reasonably mobile within plants, and in cases of limited supply, higher concentrations can be found in the roots compared to the leaves. Leaf concentrations tend to increase as molybdenum availability improves. Among all minerals, molybdenum has one of the lowest requirements for plants, except in specific species where nickel may be even less required(Shukla*et al*.,2014).The role of molybdenum as a plant nutrient is closely tied to its ability to undergo changes in valency as a component of metalloenzymes. In plants, only a limited number of enzymes have been identified to contain molybdenum. Two crucial molybdenum-containing enzymes found in higher plants, nitrogenase and nitrate reductase, play vital roles in crop production. Nitrogenase is essential for all biological systems involved in nitrogen fixation, and each nitrogenase molecule contains two molybdenum atoms, which are associated with iron. Consequently, plants that rely on nitrogen fixation, particularly those with root nodules, have a relatively high demand for molybdenum. As expected, the growth of plants dependent on nitrogen fixation is notably enhanced when molybdenum is applied to deficient soils(Shukla*et al*.,2014).

Molybdenum Deficiency Symptoms

- Greening of veins giving mottled appearance, along with the interveinal chlorosis is observed. Cupping or rolling of leaves along with the marginal scorching is also observed (Jain,2007).

Micronutrients Role in Food Grain Production

The rising trend in the country's use of micronutrient fertilizer over time compared to the amount of food grains produceddemonstrates the significance of micronutrients in the production of sustainable food(Shukla et al.,2019).Zn and b fertilizer are thought to contribute roughly 29 Mt of rice equivalent yields to the production of current food crops (Shukla and Behera., 2011). It is important to recognize that the contribution of micronutrients because their use has been steadily rising and is improving crop productivity. through the usage of zinc sulphate fertilizer was the largest (1,88,300t) and after that by - nese sulphate (2,740t) and copper sulphate (1,369t) during 2015–16 [Shukla *et al*.,2019]. According to a latest record of micronutrient consumption (FAI, 2016). Molybdenum, iron, and copper are used in reverse order from zinc, with 30% going to vegetable and fruit crops and 70% going to field crops(Shukla *et al*.,2019).

Managing Micronutrient for Higher Crop Production

Based on the availability and demand of micronutrients in the soil-plant system, micronutrient management must be implemented. Crop, soil types, degree of deficiency, source, technique, timing, rates, and frequency of application all affect how it changes.Important factors like micronutrient requirements of the crops and cropping system, ranges within their deficiencies and toxicities, low use efficiency of micronutrients, residual availability, etc. need to be carefully checked before planning for replenishment of the micronutrient removed by the crop and depleted from the soil through micronutrient management (Shukla *et al.*, 2014).

<u>Zinc</u>

Among various different sources of zinc element selected for efficacy under different climatic condition, $ZnSO_4.7H_2O$ claimed that it is better source in management of zinc deficiency (Takkar*et al*., 1989; Shukla et al., 2009; Shukla and Behera., 2012).However, chelated zinc performed $ZnSO_4.7H_2O$ for maize and rice throughout multiple trials. The best zinc application rates changed depending on the crops, soil types, and degree of zinc shortage. The results of numerous field tests showed that 2.5 to 10 kg of zinc per hectare in the form of $ZnSO_4.7H_2O$ were the most successful in reducing its deficiency and maintaining good soil productivity in the majority of the crops cultivated on various zinc deficient soils(Shukla *et al*.,2019). Considering the efficiency of Zn applied through soil is so low (2–5%), attempts have been undertaken to develop efficient and inexpensive Zn application techniques. Top dressing was found to be inferior to the broadcast and mixed application of zinc to the soil or the positioning of its band below the seed. Other Zn application techniques include seed soaking or coating in Zn solution, side-dressing or side-banding, foliar spraying of 0.5 to 2.0% $ZnSO_47H_2O$ solution, and side-dressing or side-banding. When it comes to preserving high agricultural productivity of rice, sugarcane, and vegetables, the results of seedling root dipping in ZnO are uncertain(Shukla *et al*.,2019). Due to a number of restrictions and limitations, farmers have not yet been able to use seed soaking, ZnO slurry root dipping, or even foliar application.

Iron

Iron chlorosis tends to occur in upland crops, particularly those developed on soils that are low in iron and high in phosphorus and bicarbonate. These crops include rice, sorghum, groundnuts, sugarcane, and chickpea. The most significant source for treating the country's iron shortage is ferrous sulphate, that includes 19.5% to 20.5% Fe. However, other sources of Fe have been utilized to make up for its deficiencies in crops, including Fe-EDTA (9–12% Fe), Fe-EDDHA (10% Fe), pyrite, biotite, and organic manures (FYM 0.15% Fe), chicken and pig manure (0.16% Fe), and sewage sludge (Shukla *et al*.,2019). Fe deficiency in majority of the crops was largely addressed by foliar applications of 10–12 kg FeSO4/ha or soil applications of 50–150 kg $FeSO_4$/ha (Takkar*et al.,* 1989).Due to the quick transition from Fe^{+2} to Fe^{+3}, the rates of soil application of Fe were highly high and therefore uneconomical. Farmers refrain from using Fe^{-}chelates as a source of fertilizer due to their expensive cost. $FeSO_4$ foliar spray was proven to be more effective and successful than soil application at controlling Fe-chlorosis in horticultural crops such tomato, chilli,peanut, and sugarcane (Shukla *etal*., 2019).

Manganese

Due to soil application's failure to prevent oxidation of applied Mn, specifically in high pH soils, severe Mn absence is challenging to treat. Although it must be done annually, foliar spraying of $MnSO_4$-H_2O is a rapid and effective method of treating wheat's Mn shortage(Shukla *et al*.,2019). When it came to considerably enhancing wheat grain production, $MnSO_4$H2O showed to be 1.5 and 10 times more effective than Mn-frits and MnO_2, respectively. Mn rehabilitation to the soil and to the leaves of the wheat aided in its high yield. However, it was discovered that applying 0.5% $MnSO_4$ solution topically was more efficient and cost-effective than applying 50 kg $MnSO_4$/ha of soil (Shukla *et. al*., 2019).

Copper

There is virtually little copper shortage in Indian soils. With soil application of 5.0 kg Cu/ha to the first crop, either foliar or soil application of Cu to the soybean-wheat cropping system on typical Ludhiana test plots proved equally efficient in addressing the shortage(Shukla *et al*.,2019).

The yield of soybean grain rose from 2.18 to 2.35 t/ha after foliar spraying with a 0.2% $CuSO_4$ solution. Wheat after receiving soil-applied Cu had no discernible residual effects (Shukla *et al*.,2019).

Boron

One of the major nutritional issues influencing crop production in acidic and calcareous soils is a lack of boron. To fix this deficit, borax or sodium tetra-borate decahydrate ($Na_2B_4O_7.10H_2O$, fertiliser grade, 10.5% B) is frequently added to the soil(Shukla *et al.*,2019).Boric acid (H_3BO_3, 17% B) and solubor (fertiliser grade $Na_2B_4O_7.5H_2O$+ $Na_2B_4O_7.10H_2O$, 19% B) are mainly used as foliar sprays. Borax application rates, however, vary based on the crop, the season, and the kind of soil in order to achieve sustained, optimum productivity(Shukla *et al*.,2019).For rabi (spring) crops such mustard, maize, sunflower, onion, and lentil, the application rate was 1.5 kg B/ha; for kharif (summer) crops including groundnut, maize, onion, yam, bean, and black gramme, the application rate was 2.0–2.5 kg B/ha (Sakal and Singh, 1995). The rates of B were moderate (0.75 and 1.5 kg B/ha) for maize, wheat, and rice; relatively low (0.5-0.75 kg B/ha) for sesame and linseed in coarse-textured entisol; and 1-2 kg B/ha for maize, wheat, and rice; as well as 1-2 kg B/ha for chickpea, pigeon pea, groundnut, sunflower, and mustard in calcareous and clay-textured verti (Dangarwala*et al*., 1994).

Future Research Strategies

The selection and development of crops and cultivars that are effective at using micronutrients should be prioritized. Furthermore, it is critical to advise farmers, especially those growing crops in soil deficient in micronutrients, to use nutrient-efficient crop rotation techniques.Geographic Information Systems (GIS) should be used to routinely examine micronutrient deficits in different crop rotations and soils. Every two to three years, the entire state should be subject to a thorough examination(Rahman *et al*.,2020). Repeated surveys should be carried out every four to five years to keep track of changing patterns. The critical thresholds for micronutrient levels in the primary crops farmed in the state must also be improved, taking varied soil types into account.There is currently little information available on the state's increasing shortages in copper (Cu) and boron (B), as well as how different crops react when Cu and B are applied to soils that are weak in these micronutrients(Rahman *et al.*,2020). More field trials must be started in order to gather information on crop responses, identify crucial thresholds, and create effective management strategies for these inadequacies in actual field settings.(Sadana *et al.,* 2010)Future crop output might be improved by investigating the possible creation of genotypes that are effective at using micronutrients or have tolerance for and resistance to micronutrient shortages.

Conclusion

Acceptance of new, modern intensive characters with high yielding quality culitvars has resulted in better production but an imbalance in nutrient supplying has caused micronutrient deficiency in soils. A study suggested that, after being collected more than 20 lakh soil samples, from 508 districts the results came out to be- 36.5% soils are Zn deficit, 12,8% soils are Fe deficit, 7.1% soils are Mn deficit, 4.2% soils are Cu deficit and 23.2% soils are B deficit. Supplying of micronutrients in a well-planned fertiliser schedule has increased the internal using efficiency of NPK. Therefore, proper micronutrient management depending upon soil type, area of cultivation, severity of deficiency needs to be done to provide sustainability in soils to maintain soils as well as human health.

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