July - Sept 2011
Vol. 4 No. 2

IMMA NEWS

Indian Micro Fertilizers Manufacturers Association

Sugary Exudation - Cu

Bronzing in Sorghum - Zn

Fruit cracking in Tomato - Ca & B

Whiptail in Cauliflower - Mo

Rs. 10/-

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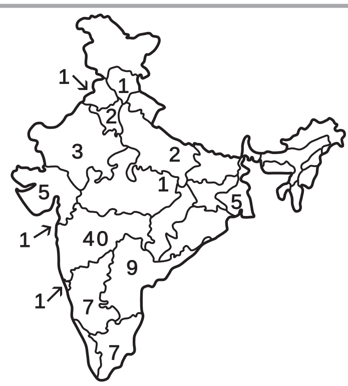

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from the editor's desk

To reap the qualitative and quantitative produce one has to follow the Integrated Nutrient Management approach is a known fact. And imbalance therein will lead to low yields with impaired quality, abnormality and further leading to disease attack.

Dr.S.K.Ray from Nagaland has highlighted the 'Role of Micronutrients and Deficiency Symptoms thereof with special reference to North East Hill regions'. Dr. Yadav and Dr. Kanthaliya in their article have given emphasis on 'Role of Copper in Crop Production'.

Dr. Kausadikar with Dr.Sayed Ismail in his article has elaborated the mechanism of Disease Resistance in relation to Crop Nutrition.'

The changing trend in application shows that there is an inclination towards 'Preventive Use of Micronutrients' than earlier 'Curative Use'

Invitation for Technical Data

We are publishing 'IMMA News' Bulletin every quarter with Technical Data on Fertilizers in general and Micronutrient Fertilizers in particular. We do forward the same as an complimentary to the Agriculture Scientists & officers, all over India.

We request all the readers to please send us Technical matter to be published in our 'IMMA News', which will assist the extension officers to disseminate your ideas to farmers, to increase crop yields.

ANNOUNCED

S.N. Ranade Memorial Awards Instituted By IMT Group Companies for Excellence in Micronutrient Reserch in the field of Agriculture have been declared on 19th July by the Chairman - Dr. Shrikant Ranade at Pune. These awards consist of a Cash Component, a citation and a silver memento.

Dr. M.A. Shankar

SENIOR SCIENTIST AWARD : A cash prize of Rs.51,000/- is being individually conferred upon Dr. M.A. Shankar from Hassan, Karnataka and Dr. K.P. Patel from Anand, Gujrat.

Dr. Shankar is the Dean of College of Agriculture in Hassan, Karnataka State. His Contribution is in the Management of Micronutrients with special reference to Zinc and Boron for enhancing productivity of Dryland crop such as millets, legumes and oilseeds.

Dr. K.P. Patel

Dr. Patel is a Research Scientist, ICAR Co-ordinated Project on Micronutrients of Soils and plants. His major research work has been on Management of Micronutrients with special reference to Iron, Manganese, Zinc. Copper and Boron in soils of Gujrat State for higher productivity of fruit crops and research in delineating of Micronutrient deficient areas in Gujrat in soils and also in Evaluation of efficacy of various grades of Micro nutrient Mixture Fertilizers in Gujrat State.

Dr. Mitali Mandal

BEST Ph.D. THESIS AWARD : A cash prize of Rs. 25,000/- is being conferred upon Dr. Mitali Mandal form Bidhan Chandra Vishwa Vidyalaya from Mohanpur, West Bengal. She has been honored with this award for her work on 'Distribution, transformation and Interactions of Boron in Soil Ecosystem in relation to growth and nutrition of Rape Seed.' Presently Dr. Mandal is pursuing further research on Micronutrients in soils of different agro-climatic zones of West Bengal.

While announcing the awards, the chairman - Dr. Ranade said, "Shri. S.N. Ranade had predicted the need for Micronutrients in Indian Agriculture as early as in 1957 and he had engaged himself in dissemination of knowledge on Balanced Plant Nutrition with Micronutrients to farming community since then. Today the need of Micronutrients is well understood by the farmers and increasing awareness on use of Micronutrients is observed. With this gesture, we wish to encourage the new generation of young scientists to take up the research work in plant Nutrition & Micronutrients. Research to meet newer challenge in Food Security and Human Nutrition arising with changing scenario."

Respecting the founder's insistence on simplicity, these awards are directly sent to the recipients and no separate award ceremony is held.

Importance Of Micronutrients Under North Eastern Hill (NEH) Regions

Dr. *Sanjay Kumar Ray*

Subject Matter (Soil Sciences) ICAR Complex fer NEH Region, KVK, Wokha, Nagaland - 797111

Plants require altogether 35 elements, out of which 16 elements are considered as essential elements for its growth and development. The essential plants nutrients can be further divided into two groups, i.e. macro and micro nutrients. Micronutrients are elements which are essential for plant growth, but are required in much smaller amounts than those of the primary nutrients; nitrogen, phosphorus and potassium. The essential micronutrients are boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), zinc (Zn), and chloride (Cl); while chloride is a micronutrient, deficiencies rarely occur in nature. Deficiencies of micronutrient drastically affect growth, metabolism and reproductive phase in plants. Widespread deficiencies of micronutrients has been found in Indian soils and these micronutrient deficiencies have been verified in many soils through increased use of soil testing and plant analyses. Under north eastern acid soil conditions the deficiency of Mo and B is prompt and deficiency of Zn also found under coarse textured acid soils but the availability of Fe and Mn is found at toxic level, especially under submerged conditions.

Why micronutrients become more important?

Now a day micronutrient becomes more important because-

- Introduction of hybrid and high yielding variety (HYV) removes higher amount of micronutrients from soil and increase plant micronutrients demand
- Intensive cropping system (3-4 crops in a year)
- Lack of organic inputs application
- Application of only primary / macro nutrients during growth periods
- Leaching losses of few micronutrients (B) by high rainfall especially under coarse texture soil
- High acidity also aggravates few micronutrient deficiencies (B, Mo)

Criteria for essentiality of micronutrients

- Plants unable to grow normally or complete its life cycle in absence of any micronutrients
- Role of each micronutrients are specific and cannot replaced by the other micronutrients
- Micronutrients play direct role in metabolism
- The deficiency symptoms of the micronutrients can be corrected or prevented by the application of that micronutrient only.

Importance of essential micronutrients on crops

Zinc (Zn) : Zn is essential micronutrient; on an overall study basis it was found that the deficiency of Zn is more common compared to other micronutrients. The proportion of soil test samples it was found to be deficient of Zn were 49%. Indian soils are generally considered zinc deficient if it tests value less than 0.6 mg DTPA- extractable Zn kg-1 soil. Zinc involves in various enzyme systems for energy production, protein synthesis, and growth regulation and zinc-deficient plants can exhibit delayed maturity. Zinc is not mobile in plants so zinc deficiency symptoms occur mainly in new growth; therefore, constant application of available zinc is needful for optimum growth crop. Zinc deficiencies are mainly found on sandy soils low in organic matter and on organic soils. Zinc deficiencies occur more often during cold, wet spring weather and are related to reduced root growth and activity as well as lower microbial activity decreases zinc release from soil organic matter. Zinc uptake by plants decreases with increased soil pH and the uptake of zinc also is adversely affected by higher levels of available phosphorus and iron into soils. The crops like banana, guava, pineapple, rice, potato, tomato, maize, beans, soybean, onion, black gram and citrus are highly sensitive to Zn deficiency.

Symptoms:

- The most visible zinc-deficiency symptoms are short internodes (rosetting) and a decrease in leaf size.
- Chlorotic bands along the midribs of corn, mottled leaves of dry bean and chlorosis of rice
- Loss of lower bolls of cotton and narrow, yellow leaves in the new growth of citrus also have been diagnosed as zinc deficiencies.
- Stunted growth of plants. Flowering, fruiting and maturity can be delayed.
- New leaves of maize plant emerge white in colour, which is known white bud

The common Zn fertilizers are zinc sulphate (21 & 33% Zn) and zinc-EDTA (12% Zn), while $ZnSO_4$ is suitable for soil application @ 5-30 kg ha-1 (these rate vary / depends based on native Zn availability of soil) and Zn-EDTA is suitable for foliar application @ 1%. Under NEH region it has been observed that the requirement of Zn was 12.5 kg Zn ha-1 for optimizing the yield of rice and the positive response also obtained from the crops like citrus, maize, black gram and green gram.

Boron (B) : The Zn deficiency is dominant micronutrient scenario, but it is time to recognize that B deficiencies now need to be taken seriously. Close to 33% out of 36800 soil samples analyzed have been found to be deficient in B. The problem has been reported to be more extensive in the eastern and NE states. A primary function of boron is related to cell wall formation, and the growth of the plant may be stunted under boron deficient soil. Sugar transport, flower retention and pollen formation and germination also may be affected for boron deficiency. Seed and grain production are reduced with low boron supply and the boron deficiencies are mainly found in acid, sandy soils in regions of high rainfall, and those with low soil organic matter. The borate ions are mobile in soil and can be leached from the root zone. Boron deficiencies are more pronounced during drought periods when root activity is restricted. Soils are considered deficient if the soil test value of B is less than 0.5 mg B kg-1 soil (hot water extractable).The crops like cabbage, cauliflower, sugar beet, rapeseed, pear, rose, sunflower, citrus, papaya and pineapple are highly sensitive to B deficiency.

Symptoms :

· Boron-deficiency symptoms first appear at the growing points. This results in a stunted appearance (rosetting), barren ears due to poor pollination, hollow stems and fruit (hollow heart) and brittle, discolored leaves and loss of fruiting bodies.

- Plant growth is retarded and leaves turn yellow or red
- Deficiency is often found to be associated with sterility and malformation of reproductive organs
- Crop produces abnormalities like corking and pitting of fruits in tomatoes, hollow stem and bronzing of curd in cauliflower etc.

The common B fertilizers are borax (10.5% B) and boric acid (20% B), and these fertilizers can be applied @ 5.6-23.6 kg ha-1, although the rate depends on the native ability of boron in the soil. Under NEH region on an average 10kg B ha-1 can be applied for obtaining desirable yield of crops.

Molybdenum (Mo) : The availability of Mo is more often associated with the pH of soil and the application of Mo is naturally require where the soil pH is less than 6.0-6.5. The deficiency also found under coarse texture soil with lower in moisture availability. A soil generally classified as deficient in Mo if it test value less than 0.2µg (micro gram) Mo gm-1 soil (Griggs reagent). Molybdenum is directly involved in enzyme systems relating to nitrogen fixation by bacteria growing symbiotically with legumes. Nitrogen metabolism, protein synthesis and sulphur metabolism may be affected by the deficiency of molybdenum. Molybdenum has a significant effect on pollen formation, so fruit and grain formation. As the requirement of molybdenum is so low, most plant species do not exhibit molybdenum-deficiency symptoms. These deficiency symptoms in legumes are mainly exhibited as nitrogen-deficiency symptoms because of the primary role of molybdenum in nitrogen fixation. Unlike the other micronutrients, molybdenum-deficiency symptoms are not confined mainly to the youngest leaves because molybdenum is mobile in plants. Molybdenum deficiencies are found mainly on acid, sandy soils in humid regions. The uptake of molybdenum by plants increases with increasing the soil pH, which is opposite that of the other micronutrients. Molybdenum deficiencies in legumes may be corrected by liming acid soils rather than by molybdenum applications. However, seed treatment with molybdenum sources may be more economical than liming in some areas. The crops like maize, cotton, cauliflower, broccoli, spinach, lettuce, radish, citrus, beans and specially legumes are sensitive to Mo deficiency.

Symptoms:

- The characteristic molybdenum-deficiency symptom in some vegetable crops is irregular leaf blade formation known as whiptail (for cauliflower and broccoli), but interveinal mottling and marginal chlorosis of older leaves also have been observed.
- Downwards cupping in radish and scald in beans
- Imbalance of various amino acids

Ammonium molybdate (54% Mo) and sodium molybdate are common Mo fertilizer is available in the market and it can be applied @ 1-2.3 kg ha-1 for soil and 0.028-0.035 kg ha-1 for foliar spray respectively. Under NEH regions application of 1 kg Mo ha-1 along with lime results the higher yield for the crops like green gram, black gram, groundnut and sesame.

Iron (Fe) : Fe plays important role for development of chlorophyll and transfer of energy within the plant. It also constitutes certain enzymes and proteins. Fe regulates plant respiration, plant metabolisms and also involve in N fixation. Iron is associated with sulphur in plants to form compounds that catalyze other reactions. Iron deficiencies are mainly manifested by yellow leaves due to low levels of chlorophyll. Leaf yellowing first appears on the younger upper leaves in interveinal tissues. Severe iron deficiencies cause leaves to turn completely yellow or almost white, and then brown as leaves die. Iron deficiencies are found mainly on calcareous (high pH) soils, although some acid, sandy soils low in organic matter also may be iron-deficient. Cool, wet weather enhances iron deficiencies, especially on soils with marginal levels of available iron. Poorly aerated or compacted soils also reduce iron uptake by plants. Uptake of iron decreases with increased soil pH, and is adversely affected by high levels of available phosphorus, manganese and zinc in soils. Under NEH regions the deficiency of Fe has not been found, therefore, toxicity of Fe is more important than deficiency of Fe under this region. The Fe toxicity is primarily pH related and occurs where the soil pH has dropped sufficiently to create an excess of available Fe. Excess Fe can result in dark green foliage, stunted growth of tops and roots, dark brown to purple leaves on some and Mn. Iron uptake can be reduced after application of higher doses of K, Zn and P. Toxicity of iron also can release in addition of liming materials into soil.

Manganese (Mn) : Mn play important role for assimilation of CO2 during photosynthesis and NO3 during synthesis of chlorophyll. The Mn play important role in the formation of riboflavin, ascorbic acid, carotene and in electron transport during photosynthesis. It also activates fat forming enzymes. Interveinal chlorosis is a characteristic manganese-deficiency symptom. In very severe manganese deficiencies, brown necrotic spots appear on leaves, resulting in premature leaf drop. Delayed maturity is another deficiency symptom in some species. Whitish-gray spots on leaves of some cereal crops and shortened internodes in cotton are other manganese-deficiency symptoms. Manganese deficiencies mainly occur on organic soils, high-pH soils, sandy soils with low in organic matter, and on over-limed soils. Soil manganese may be also less available in dry, well-aerated soils, but can become more available under wet soil conditions when manganese is reduced to the plant-available form. Conversely, manganese toxicity can result in some acidic, high-manganese soils. Uptake of manganese decreases with increased soil pH and is adversely affected by high levels of available iron in soils. Mn deficiency has not been reported under this region, although toxicity of Mn is a relatively common problem compared to the other micronutrients toxicity on soils having soil pH below 5.5. The main symptoms of Mn toxicity are drying of leaf tips and stunted roots (measles). In acid soils, apart from low pH and toxicity of Mn may decrease the availability of P and Mo. Under submerged/ water logged conditions toxicity of Mn increase and this toxicity of Mn under acid soil conditions can be decreased only after application of liming.

Copper (Cu) : Cu is the most immobile micronutrient. Copper is necessary for carbohydrate and nitrogen metabolism, so inadequate copper results in stunting of plants. Copper functions as a catalyst in photosynthesis and respiration. It is also a constituent of several enzyme systems involved in building and converting amino acids to proteins. It plays important role in metabolism of carbohydrate and protein and also in formation of lignin in plant cell walls and prevent from wilting. Copper deficiencies are mainly reported on organic soils (peats and mucks), and on sandy soils with low organic matter. Under acid soil increase Cu uptake and alkali soil inhibits Cu uptake. Increased phosphorus and iron availability in soils decreases copper uptake by plants. The deficiency symptoms yet not have been reported under NEH region, although toxicity of Cu may depress tillering. The main Cu containing fertilizers are CuO (75% Cu) and CuSO4 H2O (35%Cu). Cu can be applied to the crop @ 2.3-20 kg ha-1.

Chlorine (Cl) : Chlorine is thought to be associated with the evolution of oxygen during photosynthesis. Chlorosis and over all wilting of younger leaves is the main deficiency symptoms of Cl. Burning of leaf tips or margin, bronzing, premature yellowing and leaf fall are the chloride toxicity symptoms. Because chloride is a mobile anion in plants, most of its functions relate to salt effects (stomatal opening) and electrical charge balance in physiological functions in plants. Chloride also indirectly affects plant growth by stomatal regulation of water loss. Most soils contain sufficient levels of chloride for adequate plant nutrition. However, reported chloride deficiencies have been reported on sandy soils in high rainfall areas or those derived from low-chloride parent materials. Chloride deficiency can be correct after application of KCl as potassium fertilizer.

Conclusion : Micronutrients are as important as the primary and secondary nutrients for plant nutrition. However, the amounts of micronutrients required for optimum nutrition are much lower. Micronutrient deficiencies are widespread because of increased nutrient demands from the more intensive cropping practices. Soil tests and plant analysis are excellent diagnostic tools to monitor the micronutrient status of soils and crops. The numerous micronutrient fertilizers are on the market while some industrial by-products are used as micronutrient fertilizers because of their lower cost. The most micronutrient fertilizers are applied to soils and through foliar sprays but the choice of micronutrient source depend on the method of application, compatibility with the NPK fertilizer, convenience of application, and the relative agronomic effectiveness and cost per unit of micronutrient. Soils of NEH regions are acidic in reaction which increases the deficiency of several micro nutrients like Mo, B and Zn. This deficiency inhibits different metabolic and enzymatic activity and finally on the growth of different crops, especially for legumes. Soil acidity simultaneously increases the toxicity of Fe and Mn, especially under submerged conditions. Therefore, application of deficient micronutrients (Mo, B and Zn) along with lime and organic manures may be successful and profitable soil management practices under NEH regions.

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Patiram and T. Ramesh (2008) Technologies for Soil and Soil Fertility Management of North Eastern Region, ICAR Research Complex for NEH Region, Umroi Road, Umiam-793103, Meghalaya.

Tandon, H.L.S (2005) Methods of Analysis of Soils, Plants, Waters, Fertilizers and Organic Manures, Fertilizer Development and Consultation Organisation 204-204A Bhanot Corner, 1-2 Pamposh Enclave, New Delhi-110048 (India)

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Role Of Copper In Crop Production

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Copper (Cu) is an essential nutrient for plant growth, requires in a small amount and therefore is classified as a micronutrient. The Indian soils contain 11-141 mg kg-1 total amounts of this nutrient, but its availability to the plant varies between 0.15- 5.33 mg kg-1. The amount of Cu available to plants varies from soil to soil. The finer-textured mineral soils generally contain the highest amounts of Cu while lowest concentrations are associated with the organic or peat soils. Availability of Cu is related to soil pH. As soil pH increases, the availability of this nutrient decreases. Copper is not mobile in soils; however it is attracted to soil organic matter and clay minerals.

Function of copper in Plant Growth

- Copper is an important component of proteins found in the enzymes that regulate the rate of many biochemical reactions in plants. Plants would not grow without the presence of these specific enzymes. Copper is essential for many plant functions. Some of them are:
- It functions as a catalyst in photosynthesis and respiration.
- It is a constituent of several enzyme systems involved in building and converting amino acids to proteins.
- Copper is important in carbohydrate and protein metabolism.
- It is important to the formation of lignin in plant cell walls which contributes to the structural strength of the cells.
- Copper improves the flavor and the sugar content of the fruits and it also enhances the storage ability of the fruits.

Factors Affecting Copper Availability in the soil

- Plant Root Growth: Copper is the most immobile micronutrient. Therefore, anything that inhibits new root growth will inhibit Cu uptake.
- Soil pH: Acid soils increase Cu uptake and high pH inhibits its uptake.
- Organic Matter: Copper is readily and tightly complexed by organic matter, therefore high soil organic matter levels reduce Cu availability.
- Flooding: Waterlogged soils can reduce Cu availability in the soil. However its availability incr eases when the soil becomes dry.
- Cu: Zn Balance: High Zn levels will reduce Cu availability.
- Cu: N Balance: High N uptake in the presence of marginal Cu levels can lead to a reduction of Cu transport into the growing tips of plants.
- Cu: P Balance: High soil and plant P levels can reduce Cu uptake due to reduced soil exploration by mycorrhizae associated with plant roots.
- N Stress: Low N availability decreases the vigor of plants to an extent that it may fail to take up adequate amounts of many other nutrients. Copper uptake can be affected in this way.

Copper Deficiency Symptoms in plants

- Young tissues show chlorosis, distortion, and necrosis (death). The death of the growing points often leads to excessive tillering in cereal crops and excessive branching in dicots (non-grass crops).
- Some vegetables show a blue-green color before advancing to chlorosis.
- Excessive wilting, lodging and reduced disease resistance result from the weak cell walls caused by Cu deficiency.
- Copper deficiency often causes a complete failure to set flowers.
- Reduced seed and fruit yield is caused mainly by male sterility. Lettuce and onions most commonly manifest visible symptoms with only a slight deficiency occurring.

Copper Toxicity Symptoms in plants

Copper should not be applied to soils without a demonstrated need through soil and plant analysis. Toxic effects from over-application can last many years. Symptoms appear in young tissue and include; dark green leaves followed by induced Fe chlorosis in which the leaves may appear nearly white; thick, short, or barbed-wire looking roots which can be mistaken for chemical damage; depressed tillering.

Predicting the Needs

The need for Cu in a fertilizer program can be predicted from either plant analysis or soil testing. Interpretations for various concentrations of Cu in plant tissue are summarized in Table 1.

Table 1. Interpretation for concentration (ppm) of Cu in plant tissue.

Crop	Plant Part Sampled	Time of sampling	Deficient	Low	Sufficient	High	Excessive
Alfalfa	Top 6 inches	Bud	<3.0	3.0-7.0	7.1-30.0	30.1-50.0	>50.0
Corn	Ear leaf	Silking	<2.0	2.0-5.0	5.1-20.0	20.1-50.0	>50.0
Soybeans	Top trifoliate	Flowering	<5.0	5.0-9.0	9.1-30.0	30.1-50.0	>50.0
Wheat	Top leaves	boot	<3.0	3.0-5.0	5.1-20.0	20.1-50.0	>50.0

The results of the analysis of plant samples can indicate what has happened in the past, but cannot reliably predict future needs for Cu. The results of a soil test are a much better predictor of the need for Cu in a fertilizer program. The amount of available Cu is measured by extracting the soil with a DTPA solution. The concentration of Cu in the extract is then measured. This procedure is the most reliable and accurate for measuring Cu in soils. . Copper recommendations based on soil tests are listed in Table 2.

Table 2. Soil test interpretation and recommendations for Cu to be used.

	Application of copper	
Copper in Soil	Broadcast/ Incorporated	Foliar application
ppm	Kg ha-1	(%)
0.0-2.0	5.0	0.25 at intervals of
		15 days

Copper Sources and their Management

Some important Copper containing fertilizer materials are presented in table 3. Excess Cu applications can easily damage plant roots and leaves, so proper application rates and methods are important. Soil applications of Copper materials can have an extremely long residual effect in the soil. Therefore, records must be kept on the total amounts applied to fields. If a foliar Cu product is "basic" in nature (the pH of the Copper product/carrier mixture is greater than 7.0), the potential for, and severity of foliar damage can be reduced. Good responses have been obtained from foliar applications of Copper-containing fungicides. The recommended rates of Cu listed in Table 2 are suggestions for either broadcast or foliar applications. The rates suggested for broadcast applications are intended to correct deficiencies and should be incorporated before seeding. Foliar applications of Cu can be an effective way to correct Cu deficiencies in standing crops. The stage of growth at the time of application has a major influence on the effectiveness of the fertilizer.

Table 3. Copper containing fertilizer materials

Product	Chemical formula	Copper (%)
Copper sulphate monohydrate	$CuSO_4H2O$	36
Copper sulphate pentahydrate	$CuSO_45H2O$	25
Cupric oxide	CuO	75
Copper chloride	$CuCl_2$	17
Copper chelates	CuEDTA	8-13

Summary

The micronutrient Cu is an important consideration for crop production. The soil test for Cu is an excellent predictor of the need. Broadcast applications incorporated before planting are recommended to correct a deficiency. Foliar applications are suggested if deficiency symptoms appear during the growing season.

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Role Of Nutrients In Disease And Pest Resistance Mechanisms

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Mineral nutrients are essential for plant growth and development and are important factors in plant-disease interactions. In general, healthy, well-nourished plants resist or tolerate diseases better than weak, malnourished plants. How each nutrient affects a plant's response to disease is unique to each plant-disease complex. The purpose of this article is to briefly summarize some of what we know about plant mineral nutrition and how different nutrients affect diseases, pests and overall crop performance.

Although nutrient-pathogen interactions are not well understood, plant nutrients may affect disease susceptibility by changing internal functions that create a more favorable environment for disease. Pathogen infection alters the plant's physiology, particularly the uptake, transport and use of mineral nutrients. Pathogens may immobilize nutrients in the soil or in infected tissues. They may also interfere with nutrient and water movement or water use by the plant, inducing additional stresses. Such infections can cause root starvation, wilting and plant decline or death, even though the pathogen itself may not be directly harmful. Still other pathogens may themselves utilize nutrients, which reduces nutrient availability and increases the plant's susceptibility to infection. Soil-borne pathogens commonly infect plant roots, reducing the plant's ability to take up water and nutrients. The resulting nutrient deficiencies may, in turn, lead to secondary infections by other pathogens.

There are at least 17 mineral nutrients that are essential for normal plant growth and development. Mineral nutrients are often viewed simply as plant food necessary for better plant growth and yield. Although disease resistance is also controlled by genetics and balanced plant nutrition , mineral nutrition can have an influence on plant resistance or susceptibility to pathogens and pests. In addition, some disease-resistant genes in plants will only activate via specific environmental stimuli. Mineral nutrition is a factor that can be easily controlled in agricultural systems through fertilizer management.

Resistance Mechanisms:

In order to complement disease and pest control methods, we must understand how mineral nutrients affect disease resistance in plants, altering how plants respond to attack by pests or diseases . There are three primary resistance mechanisms that mineral nutrition can affect:

1. Formation of mechanical barriers to resist attack primarily through the development of thicker cell walls.
2. Synthesis of natural defense compounds such as phytoalexins, antioxidants and flavenoids that provide protection against pathogens.
3. Activation of systemic plant defense mechanisms.

Plants with optimal nutritional status have the highest resistance (tolerance) to pests and diseases. Susceptibility increases as nutrient concentrations deviate from this optimum. Since the roles of mineral nutrients are well established in host-disease interaction of many crops, fruit growers should recognize the existence of such interactions and see the possibilities and limitations for disease and pest control by mineral nutrition and fertilizer applications.

Role of nutrients in resistance mechanisms:

1. Potassium (K) and calcium (Ca) play key roles in forming an effective barrier to infections. Cellulose in plant cell walls requires K. Thus, K deficiency can cause cell walls to leak cell contents, creating an environment that stimulates fungal growth.

2. When K, Ca and often nitrogen (N) are deficient, plants are more susceptible to bacterial attack. Long-term research in India with K has shown that sufficient K reduced bacterial and fungal diseases 70 percent of the time and injury from insects and mites 60 percent of the time. Unlike other nutrients, the generalization can be made for K that a sufficient supply usually increases resistance to attack by all pests. K deficiency created by over-application of dolomite or magnesium lowers this resistance.

3. Ca and boron (B) deficiencies also cause mineral imbalances that lower resistance to diseases by creating a

more favorable environment for pathogen growth.

4. A frequent symptom of B deficiency in citrus is the development of "corky" tissue along leaf veins and stems as a result of the irregular (misshapen) cell growth that occurs when B is deficient. These irregular cells are like microscopic wounds through which bacteria can enter.

5. Boron deficiency reduces fruit size and juice quality and causes premature fruit drop and death of terminal growing points on the main stem of citrus trees.

6. Parasites that live on dying tissue or that release toxins to damage or kill host plants thrive in low N situations. While, sufficient N increases plant resistance to most bacterial diseases, excessive N can have the opposite effect because rapidly growing high N tissues can have low resistance to attack. In addition, bacteria that depend on living tissue for a food source actually increase with high N.

7. Mineral nutrition also affects the formation of mechanical barriers in plant tissue. As leaves age, the accumulation of silicon (Si– a non-essential beneficial element) in cell walls helps to form a protective barrier to fungal penetration. Excessively high N concentration lowers Si content by growth dilution and increases susceptibility to diseases.

8. Copper (Cu) is a plant nutrient that is widely used as a fungicide. Its action relies on direct application to the plant surface and the infecting fungi. From a nutritional perspective, Cu deficiency leads to impaired production of defensive compounds, accumulation of soluble carbohydrates, and reduced wood development — all of which contribute to reduction in disease resistance. As Cu deficiency develops, twigs start to decline. Weak twigs will bear very small leaves of yellow-green color. Fruit splitting and fruit drop are common on citrus trees showing symptoms of Cu deficiency.

9. Soil-applied Manganese (Mn) can inhibit the growth of certain fungi. Visual factors such as leaf color are important factors in insect and mite pest attraction and susceptibility. Nutritional deficiencies discolor leaf surfaces and may increase susceptibility to pests that are attracted to yellow. For example, the Asian citrus psylla, Diaphorina citri, tends to settle on young leaf surfaces that are yellow in color.

Pest resistance mechanisms:

Three primary pest defenses of plants are:

1. Physical surface properties: color, hairs.
2. Mechanical barriers: tough fibers, silicon crystals, wood formation.
3. Chemical / biochemical: content of attractants, toxins, repellants.

Mineral nutrition affects all three defense systems. There is often a correlation between N applications (stimulation of growth) and pest attack.
B deficiency reduces the resistance to pest attack in the same way it reduces resistance to fungal infections. B is used in the synthesis of flavenoids and phenolic compounds, which are a part of the plant's biochemical defense system.

A sufficient supply of all nutrients is critical to nutrient management and sustainability of trees. Similar principles govern the effect of both micronutrients and macronutrients on disease resistance: Any nutritional deficiency hinders plant metabolism and results in a weakened plant, which lowers disease resistance.

For instance, the lack of one small ounce of Molybdenum (Mo) per acre can lower disease resistance by impeding the production of nitrate reductase. This enzyme contains two molecules of Molybdenum, and is required in the conversion of nitrates to proteins. This example also illustrates the importance of balanced nutrition that no nutrient functions in isolation from the others.

Disease resistance

One of the lesser known benefits of adequate micronutrient levels in plants is to decrease the severity of diseases. Microorganisms are sensitive to much lower concentrations of Cu, Mn and Zn than higher plants. Hence, salts of these metals have been used in various disease control products for a long time. Copper is used as a fungicide to control the growth of leaf pathogens such as mildew. A comprehensive review of this topic can be found in Graham (2008) who reported that severity of a number of root and shoot diseases is increased by micronutrient deficiencies. Foliar application of micronutrients (B, Mn, Zn) may also reduce the severity of foliar disease, such as tan spot in wheat .

Under Zn deficiency, cell membranes become leaky and release organic compounds, which attract pathogens to the rhizosphere . Zinc has been shown to suppress root-rotting pathogens, root nematode infestation and take-all infections , possibly by reducing exudation of organic compounds from roots to the rhizosphere. In wheat, Zn deficiency decreased resistance to Fusarium graminearum and to Rhizoctonia solani .

Further it is found in the research reports that Cu deficient wheat plants were more severely affected by take–all fungus than Cu adequate plants. The take-all disease is suppressed by adequate Mn supply to wheat.
Boron application has been effective in suppressing a number of fungal diseases (Graham, 2008). Some recent evidence of a beneficial role of B in disease suppression includes a reduction of Xanthomonas campestris pv. Campestris in caulifower and a reduction of the pathogenic fungus Plasmodiophora brassicae Wor in Brassica species. In addition, there is evidence that the efficacy of fungicides can be enhanced by application with B, although the mechanism remains unclear . There is uncertainty about how B suppresses disease, a role of B in lignification and phenol metabolism as both are intrinsically associated with plant defense systems and, secondly, to the role of B as a structural component of the cell wall where it strengthens the barrier to suppress pathogen infiltration (Bell and Dell,2008).

CONCLUSION

In conclusion, all essential nutrients are critical for the proper metabolic functioning of trees. A balance between macronutrients and micronutrients is needed to optimize yield of high quality fruits and maintain trees healthy and tolerant to pests, diseases and other stresses.

References:

Bell, R.W. and Dell, B. (Eds). (2008) Micronutrients for Sustainable Food, Feed, Fibre and Bioenergy Production International Fertilizer Industry Association (IFA).Paris, France, pp 49-50.

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Reinstating The S.N. Ranade Memorial Awards For Excellence In Micronutrient Research

Our Founder - Shri S.N. Ranade is known to have done pioneering work in Plant Nutrition and micronutrients and establishing the norms for micro nutrients industry in the country.

In the memory of our Founder, we had instituted awards to the scientific fraternity in India for their Excellence in Micronutrient Research. The main objective to institute these awards was to acknowledge their outstanding contribution in the field of Agronomy, Horticulture , Soil Science and Plant Nutrition in relation to Micro nutrients.

These awards were last bestowed upon in2003-04

From 2011, we have reinstated these awards in the categories mentioned below.

1. LIFETIME ACHIEVEMENT AWARD-
   Citation with a monetary prize of Rs. 1,01,000/-
   Age-55 Years and above
   Eligibility: Minimum work experience of 25 years in the field of Micronutrient Research and must have original research papers in reputed journals.
2. SENIOR SCIENTIST AWARD-
   Citation with a monetary prize of Rs. 51,000/-
   Age: 45 years and above
   Eligibility: Minimum work experience of 15 years in the field of Micronutrient Research and must have original research papers in reputed journals.
3. BEST THESIS AWARD:
   Citation with a monetary prize of Rs. 25,000/-
   Eligibility: Ph.D. degree awarded during period 2011-12 and an Outstanding Thesis in the field of Micronutrient Research.

Awardees will be selected by a panel of jury who are eminet scientist

Last date for submission of nomination is 15th March 2012

Please apply to : The Co-ordinator -

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