Chemistry of Nutrient Recycling

Agrochemicals UGE 222

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FERTILIZER MANAGEMENT OF CU AND ZN FOR HIGH FERTILIZER USE EFFICIENCY IN LOWLAND AND UPLAND CONDITION

Cu in soil:

- cupric ferrite ($CuFe_2O_4$) are important Cu containing primary minerals.
- Secondary Cu minerals include oxides, carbonates, silicates, sulfates, and chlorides, but most are too soluble to persist.
- The ‘soil Cu’ line represents Cu solubility in most soils and is closed to $CuFe_2O_4$.

Mineral Cu:

sources	Cu concentration
earth's crust	50 to 70 ppm.
Igneous rocks	10 to 100 ppm
sedimentary rocks	4 to 45 ppm
soils	1 to 40 ppm
Total soil	1 to 2 ppm

Soil solution Cu

- Solution Cu concentration is usually low, ranging between 10-8 and 10-6M.
- Cu2+ solubility is pH dependent, increasing with decreasing pH.

$$Cu^{2+} + 2H_2O \dashrightarrow Cu(OH)_2 + 2H^+$$

- Cu is supplied to plant roots by diffusion of organically bound, chelated Fe diffusion.
- Organic compounds in the soil solution are capable of chelating solution Cu2+, which increases the solution Cu2+ concentration above that predicted by Cu mineral solubility.

Form and Function of Copper

- ***Form***: Copper is taken up as Cu^{2+} (cupric ion)
- Function:
- Copper is important for photosynthesis.
- Symptoms for copper deficiency include chlorosis.
- Involved in many enzyme processes.
- Involved in the manufacture of lignin (cell walls).
- Involved in grain production.

Deficiency symptoms

- Stunted growth.
- Dieback of terminal shoots in trees.
- Poor pigmentation.
- Wilting and eventual death of leaf tips.

Factors affecting Cu availability:

- Texture
- Soil pH
- Interaction with other nutrient soil pH

- Texture

  The potential for Cu deficiency is the highest in excessively leached, coarse- textured soils.

- Soil pH:

  Solution Cu decreases with increasing pH due to decreased mineral solubility and increased adsorption.

Interaction with other nutrients

- High Zn, Fe and P concentrations in soil solution can depress Cu adsorption by roots and intensify Cu deficiency.
- Increased growth response to N or other nutrients may be proportionally greater than Cu uptake, which dilutes Cu concentration in plants.

Cu source (organic source)

- Although most animal wastes contain small quantities of plant available Cu (0.002 to 0.03%), elevated Cu levels occur in swine manure because of Cu added to the feed.
- Consequently, continued application might create toxic levels of soil Cu, especially sensitive crop like peanut.
- It is the primary benefit of organic waste application is increased OM and associated natural chelation properties that increase Cu availability.
- Cu content in municipal waste is 0.1%, but varies greatly dependent on source.

Inorganic source:

Source	formula	%Cu
Copper sulfate	CuSO4.5H2O	25
Copper sulfate monohydrate	CuSO4.H2O	35
Copper acetate	Cu(C2H3O2)2.H2O	32
Copper ammonium phosphate	Cu(NH4)PO4.H2O	32
Copper chelates	Na2Cu EDTA	13
Organics		<0.5

Zinc(Zn)

- Plant available Zn is governed predominantly by Zn mineral solubility, soil OM.
- Zn adsorbed on ,which is then adsorbed on to the CEC, incorporated in to the microbial bio mass or complexed by organic compounds in solution.
- chelated Zn is important to the transport of Zn to root surfaces for uptake

Zn in soil:

- Mineral Zn:

  Zn content of the lithosphere is about 80 ppm, and Zn in soil ranges from 10 to 300 ppm. igneous rocks contain 70ppm,while sedimentary rocks contain more Zn (95ppm)than limestone (20ppm)or sandstone(16ppm).

- Soil solution Zn:

  Soil solution Zn^{2+} is low, ranging between 2 and 70 ppb, with more than half complexed by OM. above pH7.7

Form and Function of Zinc

- ***Form***: The Zn^{2+} cation is the predominate form taken up by plants.
- Function:
- Zinc is required in a large number of enzymes and plays an essential role in DNA transcription.
- A typical symptom of zinc deficiency is the stunted growth of leaves, commonly known as "little leaf" and is caused by the oxidative degradation of the growth hormone auxin.

Zn deficiency symptoms:

- Light green ,yellow, or white areas between leaf veins , particularly in older leaves.
- Eventual tissue necrosis in chlorotic leaf areas.
- Shortening of stem or stalk internodes, resulting in rosette leaves.
- Small, narrow, thickened leaves, often malformed by growth of only part of leaf tissue.
- Premature foliage loss.
- Malformation of fruit, often with little or no yield.

Factors affecting Zn availability:

- Zn Adsorption
- Soil OM
- Flooding
- Climatic conditions
- Plant factors

Zn Adsorption

- Zn^{2+} Adsorption also occurs on the CEC of clay minerals, but does not occur to any great extent, at least compared to Ca^{2+} and Mg^{2+}.
- Zn is strongly adsorbed by magnetite($MgCO_3$), and to a lesser extent dolomite[($CaMg(CO_3)_2$],Where Zn is adsorbed in to the crystal surface at sites normally occupied by Mg atoms.
- Zn adsorption by $CaCO_3$ is partly responsible for reduced Zn^{2+} availability in calcareous soils, where Zn availability decreases with increasing $CaCO_3$ content.

Soil OM

- Zn^{2+} forms stable complexes with high molecular weight organic compounds that exist as soluble or insoluble complexes.
- With insoluble complexes, Zn availability will be reduced as in zinc deficient peats and humic soils.
- Substances present in or derived from freshly applied organic materials also have the capacity to chelate Zn^{2+}.

Flooding

- When soils are submerged, concentration of many nutrient increases, but not Zn.
- In acid soil, Zn deficiency may be attributed to increased pH under reducing conditions and subsequent precipitation of franklinite($ZnFe_2O_4$).

Climatic conditions

- Zn deficiencies are more pronounced during cool, wet seasons and often disapper in warmer weather.
- Increasing soil temperature increases Zn availability by increasing Zn2+ solubility and diffusion

Plant factors:

- Species and varieties of plants differ in their susceptibility to Zn deficiency.
- Corn and beans are very susceptible to low Zn. Fruit trees, citrus and peach are also sensitive.
- Cultivars differ in their ability to take up Zn, which may be caused by differences in Zn translocation and utilization, different accumulations of nutrients that interact with Zn, and differences in root and mycorrhizal infection

Sources of fertilizer Zn

source	Formula	%Zn
Zinc sulfate monohydrate	$ZnSO_4.H_2O$	35
Zinc oxide	ZnO	78
Zinc carbonate	$ZnCO_3$	52
Zinc phosphate	$Zn_3(PO_4)_2$	51
Zinc chelate	Na2 ZNETDA	14
Natural organics	-	1-5

Nutrient transformation in submerged soil

- To increase fertility efficiency in lowland rice
- Submerges causes in the properties of the soil because physical reaction between soil and water the biology and chemical process set in motion as a result of excess water.
- The most important changes is the conversion of the root zone of the rice plant from an aerobic environment to an anaerobic or near anaerobic .

Zinc and its role in the growth of the rice plant

- Zinc (Zn) is one of the 16 essential elements for the growth of the rice plant.
- It is a micronutrient that is needed by the rice plant in small amount.
- At least 300 grams of Zn is needed to produce one ton of rice yield.
- It is essential in maintaining high chlorophyll to carotenoid (yellow pigment) ratio in the rice plant.

Importance of managing zinc deficiency

- In Zn- deficient soils (NPK) fertilizers alone cannot provide good yield unless Zn deficiency is corrected.
- most rice fields are deficient in Zn, application of NPK fertilizers alone decreased lowland rice grain yield, whereas application of Zn as zinc oxide with NPK dramatically increased yield.

- Thank you……