ZINC AND IT'S MANAGEMENT IN CROP PRODUCTION

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INTRODUCTION :

Today more than 100 elements are known to man. Of these, sixteen elements are essential for normal plant growth. An essential element is one without which the plant cannot complete its life cycle. The 16 essential plant nutrient elements are divided into macronutrients and micronutrients as follows:

Macronutrients	Micronutrients
Carbon (C)	Zinc (Zn)
Hydrogen (H)	Copper (Cu)
Oxygen (O)	Iron (Fe)
Nitrogen (N)	Manganese (Mn)
Phosphorus (P)	Boron (B)
Potassium (K)	Molybdenum (Mo)
Calcium (Ca) 1/	Chlorine (Cl)
Magnesium (Mg) 1/	
Sulphur (S) 1/	

1/ Classified as "Secondary" nutrients.

Nine of these elements (C, H, O, N, P, K, Ca, Mg, S) are required in relatively large amounts and are designated as Macronutrients. The remaining seven are needed in smaller amounts and in certain cases only traces of them are required. These are called micronutrients. Elements such as chlorine, silicon, sodium, Vanadium and Cobalt are classed as essential when the less restrictive definition of essentiality is used and these are called micronutrients.

Zinc as an essential plant nutrient was first noted by Raulin (1869) while he was working on bioassay of zinc availability in soil with Asperiallus niger, a mould. Later on more works on evidence of the essentiality of zinc in plants were furnished by Mazy, Sommer and Lipman (1926) and Sommer (1928) who found that zinc was indispensable for the growth of barley, sunflower, buckwheat, beans etc. In India zinc deficiency was first recorded by Nene (1966) as a field problem of rice alkali soil. Thus Zinc is one of the essential micronutrient elements. Its requirement to the plant is little but in absence of this may cause serious affect on the growth of the plant. Numerous studied have indicated that Zn deficiency is a serious nutritional problem for upland crops. Zinc deficiency is widespread and recognized as an important nutritional problem throughout the world.

BRRI scientists were detected the deficiency on rice in early seventies across the country. According to an estimate at least 1.6 million hectares of land in

Bangladesh are on either the threshold level or acute stage of deficiency of zinc. Presently large acreage of zinc deficient soils in Bangladesh are being correcting with Zinc fertilizers (Zinc Sulphate) for different crops (Rice, Maize, Potato, Onion, Jute, Sugarcane, Vegetables, etc.)

Zinc deficiency is widely scattered all over Bangladesh. But most zinc deficient greater districts are: Jessore, Kushtia, Khulna, Faridpur, Barisal, Pabna, Rajshahi, Bogra, Rangpur, Dinajpur, Dhaka, Noakhali and Chittagong.

ZINC IN PLANTS

Function of Zinc

Zinc is directly or indirectly required by several enzyme systems, auxins and in protein synthesis, seed production, and rate of maturity. Zinc is believed to promote RNA synthesis which in turn is needed for protein production.

Zinc mainly functions as the metal component of a series of enzymes. The most important enzymes activated by this element are carbonic anhydrase and a number of dehydrogenases. Zinc deficiency is thought to restrict RNA synthesis, which in turn inhibits protein synthesis. Zinc is involved in auxin production. Shoots and buds of Zinc deficient plants contain very low auxin contents. This causes dwarfism and growth reduction. The net results are stunted plants and prolonged duration of growth.

Concentration and Critical Levels in Plants

Zinc concentration in Plants varies from as low as 1 ppm to as high as 10000 ppm on a dry weight basis. Concentration of Zinc commonly observed lie between 20 and 100 ppm. Plant Zn concentrations are a reflection of the available Zn levels in soils. Zinc content varies in different plants at deficient, low, normal, high and toxic levels. Thus, plant tissue tests can be of real aid in diagnosing or confirming Zn deficiency.

A quantitative association between tissue Zn concentration and growth and yield of crops exists. For several crops Zn concentration less than 20 ppm suggests the probability of Zn deficiency and value less than 15 ppm indicate sure deficiency. As compared to deficiency ranges, less is known about toxic ranges. Values about 100 ppm Zn are generally regarded in the excess range. Those above 400 ppm are suggested as toxic for some crops. Zn toxicity may develop in many plants when Zn concentration reach at 150 ppm or more.

Zinc Deficiency Symptoms

Zinc deficiency may depress plant yields as much as 50 percent without producing any symptoms. Where visual symptoms develop, they most often occur on leaves. At times these can be seen on other plant parts also. Not only the overall development of plans is affected by Zn deficiency but even the root growth is retarded. Severity of symptoms can be used as an Index to the degree of deficiency. Zinc deficiency symptoms common to many crops are:

- Stunted growth; Poor tillering; development of light green, yellowish, bleached spots in interveinal areas of the leaf, particularly the older lower leaves; in some crops brown rusty spots are also seen;
- very small leaves at the shoot tip; the shoots may fail to extend and the little leaves are frequently malformed resulting in a bushy rosetted appearance;
- dwarfism resulting from the shortening of the internodes;
- delayed flowering, fruiting and maturity;
- shoots die off and leaves may fall prematurely;
- death of the affected tissue followed by death of the plant; uneven crop stand;
- improperly developed fruits often with littlė or no yield.

Symptoms of zinc deficiency are very distinct in Rice, Maize, Citrus, Grapes, apples and potato and are described for these crops.

1. Rice :

   Lower leaves have chlorotic midribs particularly towards the base. These leaves develop brown rusty spots which coalesce and form continuous areas. In the case of acute deficiency, the whole leaf becomes brown/brown rusty and dry and plants may succumb. A Zinc deficient crop field gives a brown rusty appearance and the stand of rice is uneven.

2. Maize :

   Older leaves have yellow streaks or chlorotic striping between veins. When the deficiency is severe, it may show as a broad yellow or entirely white band between the midrib and the edge of the leaf. In severe cases, unfolding young leaves may be white or yellow; hence the name "white-bud" in maize.

3. Beans :

   The plants are stunted with yellow or pale green foliage. Veins and midribs of leaves are green, although tissue around them becomes yellowed and bronzed. Older leaves may wither and drop off.

4. Apples :

In apples Zn deficiency is frequently known as rosette disease. Young leaves become chlorotic between veins. Veins stay green leaves become crinkled, are narrow and characteristic rosettes are formed at the shoot tip.

5. Citrus :

In Zn deficient citrus trees the size of the leaves at the shoot tip is often drastically reduced (little leaf). Affected leaves have irregular creamish-yellow mottled areas on the dark back ground of the remainder of the leaf (mottle leaf).

6. Grapes :

The leaves of Zn deficient veins are small and show chlorosis.

7. Potato :

Zn deficiency symptoms usually appear on the new growth. Deficient plants show severe stunting and bronzing or yellowing of the foliage, usually around the leaf margins; starting from the tips. Youngest leaves are cupped upwards and rolled to such an extent that the terminal growth resembles that of ferns. Leaves of affected plants are smaller and their upper internodes are shorter.

Diagnosis of Zn deficiency from symptoms appears easy, but in practice it is not. The success of the method depends upon the experience of the individual with Zinc deficiency symptoms of a specific crop. The diagnosis based upon symptoms becomes uncertain if multi-nutrient deficiencies occur simultaneous. Thus, suspected deficiencies should always be confirmed by diagnostic spray, soil and plant analysis.

ZINC IN SOIL

Form of Zinc

Zinc in Soils is Present as:

- Part of the mineral structure, in particular in the ferromagnesian minerals, augite, hornblende and biotite;
- Salts such as Sphalarite (ZnS), Smithsonite ($ZnCO_3$); Zincite (ZnO) and willemite ($ZnSiO_3$ and $ZnSiO_4$);
- Absorbed Zn present on the soil exchange complex;
- Organic complexes; Soluble and insoluble;
- Water soluble; includes ionic Zn^{2+} and soluble complexes of Zn with organic

matter.

The forms of Zinc in soils considered to influence in varying degree its supply to plants are: Water-soluble Zn^{2+}, exchangeable Zn^{2+}; adsorbed Zn^{2+} on surfaces of clay, organic matter, carbonates, and oxide minerals; organically complexed Zn^{2+}; and Zn^{2+} substituted for Mg^{2+} in the crystal lattices of clay minerals.

Reported amounts of Zn^{2+} in the soil solution are very low. On average 60% of the Zn^{2+} in soil in these soils was complexed, presumably by organic matter. Plants take up zinc as the Zn^{2+} ion, and mobility of this ion in soil has an important bearing on proper nutrition of plants.

Total Contents

Total Zn in soils varies from 10-300 ppm with an average of around 80 ppm. Some highly leached acid sands are unusually low in total Zn (<30 ppm). Zinc deficiency may occur on such soils owing to inherently low Zn. Except these, the Zn status of the plants in mostly un-related to total Zinc in soils. Thus, high total Zn in soils is not always an insurance against Zn deficiency.

Available Contents and Critical Level

Plant available Zn levels Govern the Zn nutrition of crops. A small fraction of total Zn is plant available, only a few parts per million, more frequently less than one. Only 1-5 percent as available to plant of total soil Zinc. Critical level of available Zn in soils is 0.6 ppm with range 0.4-1.2 ppm. Several factors affect soil Zn availability to plants.

Factors affecting availability of zinc:

The plant availability of Zn^{2+} is conditioned by a number of soil, environmental and plant factors.

1. Soil pH

Zinc availability is highly pH dependent. It is higher in acid soils. In contrast, in alkaline soils the availability is very low. Calcareous soils are frequently Zn deficient due to the alkaline reaction. The availability of soil Zinc to plants decreases with increased soil pH, as would be expected by reason of the sensitivity of Zn^{2+} solubility to pH. Most pH induced zinc deficiencies occur within the range 6.0 to 8.0. At high pH, Zinc forms insoluble compounds such as $Zn(OH)_2$ and $ZnCO_3$ which can reduce the available Zinc in soils to lower levels.

Liming increases soil pH and depresses Zn availability. Overliming brings about severe Zn deficiencies. Some acid soils may contain toxic Zn levels.

Adsorption of Zn^{2+} by organic matter is also influenced by pH.

2. Organic Matter

It is well known that Zinc forms stable complexes with soil organic-matter components. The humic and fulvic acid fractions are prominent in Zinc adsorption.

Organic matter decomposition gives rise to certain chelating agents which contribute to Zn availability to plants. Low organic matter soils are prone to Zn deficiency, since it is seen that available Zn increases with a rise in organic matter levels in soils. More often Zn deficiency is noted on sites where surface soil containing organic matter has been scraped off. However, high organic matter soils (Peat and Muck soils) are exceptions and they also show paucity of available Zn.

3. Texture

Coarser soil fractions contain and retain low Zn. Therefore, light textured soils are generally Zn deficient.

4. Phosphorus

There are widespread reports that high phosphorus availability in soil induces Zinc deficiency. This interaction occurs mainly when plants are grown without sufficient Zinc. High phosphorus availability in soil, either native or created through excessive treatment with phosphatic fertilizers, has been shown to adversely affect Zn nutrition of several crops. The antagonistic effect of high P on Zn availability is aggravated in Calcareous soils. It is belief that P-Zn reactions in soil, such as the formation of insoluble $Zn_3(PO_4)_2.4H_2O$, are responsible for phosphorus-induced Zinc deficiency should be largely discounted. Solubility of this compound is sufficiently high that it will readily provide Zinc to plants.

5. Sulfate

The highly mobile $ZnSO_4$ complex is an important species in soils and contributes significantly to total Zinc in solution. Solubility and mobility of Zn^{2+} in soils are believed to be increased by the presence of $SO4^{2-}$ and subsequent formation of this complex. $SO4^{2-}$ supplied as gypsum decreased molybdenum uptake, which, in turn, increased concentrations of Zinc as well as iron and Manganese.

6. Nitrogen

Liberal applications of nitrogen fertilizer can stimulate plant growth and increase Zinc requirements beyond the available supply. The amount and properties of the nitrogen source and its placement in relation to the Zinc fertilizer has a notable effect on Zinc availability. Nitrogen fertilizers that are acidic forming (Ammonium Sulphate) will increase the uptake of both native and supplemental Zinc. On the other hand, products with a neutral-to-basic effect are known to depress Zinc uptake.

7. ·Bicarbonates

Forno et al (1975) found that sodium bicarbonates in the concentration range of 15 to 38 m mole reduced Zn uptake in rice shoots by 70% and in rice roots by 5%. Mikkelson and Brandon (1975) showed similar relationship for zinc immobilized in rice roots with translocation blocked to the shoots.

8. Calcium Carbonates

Zinc deficiencies are more commonly found in calcareous soils. Leeper (1952) postulated that calcium carbonate may act as a strong adsorbent for heavy metals. Jurinak and Baur (1956) reported that zinc was adsorbed in the crystal surfaces of dolomite and magnesite at sites in the lattice by replacing magnesium. Zinc was also adsorbed less strongly on calcite than magnesite and dolomite.

The effect of calcium carbonate on relation of added Zinc by three soils - black, red and alkali was studied by Tiwari and Misra (1964). It was observed that the retention of applied Zinc increased gradually with increasing doses of calcium carbonate in all the soils due to physical adsorption of ions and the colloidal surfaces and formation of some basic Zinc carbonates.

9. Iron, Copper, Manganese and Magnesium

Interactions of zinc with other micronutrients, particularly iron, copper and manganese, are next in importance to only zinc-phosphorus interaction and have been investigated in considerable detail in many countries.

Rathore et al (1973 and 1974) observed that increasing level of iron application decreased zinc uptake in Maize seed. This antagonistic effect of iron on zinc uptake was more pronounced at the initial stage of plant growth. Kinetic analysis of the uptake data reveals that zinc uptake and translocation are competitively inhibited by iron and a reciprocal relation exists between these elements during their absorption and transportation. Magnesium ions are found to interfere with zinc uptake, zinc translocation is sometimes enhanced by magnesium.

10. Flooding

At one time Zinc deficiency in flooded rice soils was believed to be confined to those with high pH or those containing $CaCO_3$. However, this problem is now also known to occur in acid soils. When soils are submerged the concentration of most nutrient elements in the soil increases, but this is not true for Zinc. In acid soils the decrease in Zinc levels may be attributed to the increase in pH following reduction. The lowering of pH that occurs when calcareous soils are submerged is normally expected to increase Zinc solubility.

11. **Temperature**

Zinc deficiency are common during cool, wet seasons and usually disappear as the weather becomes warmer. Increases in soil temperature have been shown to increase the availability of Zinc to crops.

12. **Land Levelling**

Plant available Zn is generally concentrated in surface soil and its level decreases in sub-soil horizons. Removal of topsoil, either by erosion or in the process of land shaping/levelling, exposes Zn deficient sub-soil. In either cases the probability of Zn deficiency increases.

13. **Crop Sensitivity**

Species and varieties of plants differ characteristically in their susceptibility of Zinc deficiency. A list of crops in different sensitivity groups is given below:

Sensitive Crops	Mildly sensitive crops	Insensitive crops
Citrus	Cotton	Peas
Rice	Potato	Mustard & other Crucifers
Soybeans	Tomato	Safflower
Grapes	Sorghum	Carrot
Corn	Sugarbeets	Oats
Fruit tree (deciduous)	Alfalfa	Rye
Onion	Clovers	Asparagus
Beans (Lima)	Barley	Forage grasses
Flax	Wheat	Peppermint
Castor beans		Small grains
Hops		
Pecans		
Pine		
Sudangrass		

<u>Movement of Zinc in Soil</u>

It is obvious from the foregoing that Zinc is relatively immobile in most soils. Most of the Zinc retained in the surface inch of soil and only little may downward movement occurred. The Zinc retains in soils as water-insoluble form much of it is removable with a dithizone extract. Zinc moves through the soil columns and distributes throughout the columns:

ZINC FERTILIZERS AND CORRECTION OF DEFICIENCIES

A. Source of Zinc

The primary guideline for selecting a particular material should be based on (i) agronomic effectiveness, (ii) economic advantage, (iii) ease of application, and (iv) easy local availability from dependable source. Progressive farmers should be willing to test a new product on a small part of their field to see its performance themselves before using it on their entire farm.

A number of Zinc-containing sources can be used for correction of deficiencies. Several Zinc carriers are available and are listed in the following table:

Common/trade name	Chemical formula	Zn content percent
Zinc Sulphate monohydrate	$ZnSO_4.H_2O$	36
Zinc Sulphate heptahydrate	$ZnSO_4.7H_2O$	23
Basic Zinc Sulphate	$ZnSO_4.4Zn(OH)_2$	55
Zinc Oxide	ZnO	78
Zinc Carbonate	$ZnCO_3$	52
Zinc Sulfide	ZnS	67
Zinc Phosphate	$Zn_3(PO4)_2$	51
Zinc Chloride	$ZnCl_2$	45-52
Zinc Oxide-Sulphate	$ZnO-ZnSO_4$	55
Zinc Ammonium Phosphate	$Zn(NH_4)PO_4$	37
Sphelarite	ZnS	60
Zinc dust	-	99.8
Zinc frits	-	4 (variable)
Zinc chelated sources		
Synthetic	Na_2 Zn EDTA Na Zn HEDTA Na Zn NTA	14 9 13
Natural	Zinc polyflavonoid Zinc Ligninsulfonate	10 5

Zinc Sulphate

Zinc sulphate monohydrate containing 36% Zinc, continues to be a popular fertilizer material. Zinc sulphate heptahydrate containing 23% Zinc, can be used as a fertilizer material. Zinc sulphate is used both as soil dressing and foliar sprays. It is soluble in water, readily available to field crops and low in cost. It is available in powder, crystalline and granular form.

Zinc sulphate is an inorganic sulphate salts. It contains Sulphur along with the zinc and readily soluble in water. Thus it can be used both for soil application and for foliar spray. Zinc sulphate when added to the soil, dissolve in the soil solution and react with its organic and mineral constituents. Very little of the added nutrient remains free in solution under most conditions, but these do not have to undergo any major chemical changes in order to furnish the ionic forms in which the plant roots absorb them. The sulphate (SO_4^{2-}) can also be easily leached out with drainage waters.

Zinc Oxide

Zinc oxide is less soluble than Zinc sulphate. It is often used in nutritional sprays and blending with macronutrient fertilizers. Dipping of rice roots in ZnO suspension (2-4%) is quite effective and economic for the correction of Zinc deficiency in rice. It is a low cost, high analysis Zinc carrier.

Other salts of Zinc listed in the above table are less often employed to combat Zinc deficiency. Although $Zn(OH)_2$ *minerals are not specified in the above table, they as well as ZnO and* $ZnCO_3$ *make good fertilizers in soil because they dissolve sufficiently to maintain adequate* Zn^{2+} *levels for plants. Zinc phosphate* $Zn_3(PO_4)_2$ *is less soluble than the oxides, hydroxides, or carbonates, but in soils it can be expected to supply available Zinc to plants over extended periods of time.*

Zinc Chelates

Zinc chelates are organic complexes of zinc with EDTA (ethylene diamine tetra acetic acid) and other chelating agents. Zn-EDTA contains 14 percent Zn. Zn-chelates are generally at least five times more effective than inorganic salts (except in flooded rice) on equivalent Zn basis. Chelated Zn, however, is about 15-20 times costlier, so Zn-chelates are not widely used.

Zinc frits

The fritted Zn is prepared by fusing Zn salts into glass or phosphate matrix. Due to their exceeding low solubility, frits do not leach away and thus maintain availability over a long period of time. They are however, more expensive than inorganic salts.

Zinc blends with fertilizers

In recent years Zn has been coated on, or incorporated into macronutrient carriers. The idea behind this innovation is to achieve uniform distribution of micronutrients in the field and to cut down the application costs.

Minerals and by-products

Several by-products of mining and manufacturing industries containing Zn have also been used. Zinc in these products (such as mineral sphalerite) is very slightly soluble.

Micronutrient Mixtures

In several countries a variety of proprietory products containing Zn and often other minor elements also are offered for sale. In some instances these are formulated with insecticides or other pesticides.

Organic Manures

Organic manures contain Zn and several other nutrients. This composition is extremely variable. These are seldom used as a source of Zn, but their regular applications are able to check depletion of soil Zn as a result of continuous cropping.

Continuous application of Zn-rich sewage/sludges may create toxicity problems.

Conclusion

Among the various sources of Zn, zinc sulphate is by far the most commonly used Zn carrier.

Because of the immobility of Zinc in soil, especially those that are basic or calcareous, spatial distribution of Zinc fertilizer granules or droplets plays an important role in supplying sufficient Zinc to plant roots.

B. Rate of Zinc Application

Recommended amounts of Zinc depend on crop, Zinc source, method of application, and severity of zinc deficiency. Rates usually range from 3 to 20 kg Zinc per hectare when inorganic Zinc salts are used and from 0.5 to 2 kg/ha when the Zinc source is either a chelate or an organic complex. For most field and vegetable crops, 10 kg zinc/ha is recommended in clay and loam soils, and 3-5 kg zinc/ha in sandy soil. In most cropping situations, applications of 10 kg/ha of zinc can be effective for 3-5 crops. In the case of long term perennials such as grapes, hops and tree fruits, pre-plant soil application of Zinc with higher rate of application is effective. The rates of Zinc for establishing grapes and hops is 20 kg/ha with a higher amount of 100 kg/ha of Zinc for tree fruits.

BARC recommended of Zinc for 25 crops with the range from 2 to 8 kg/ha (see Table 1).

C. Method of Zinc Application

The methods of providing Zinc fertilizers for control or prevention of deficiencies range from soil and foliar applications to tree injections. Because the mobility of Zinc can be very limited in soils, soil applications of Zinc should be worked thoroughly and deeply into the soil. The effectiveness of methods of Zinc application is largely determined by the nature of disorder, growth conditions and the nutritional status of the crop and soil. The following several options are available by which Zn can be provided:

- Soil applications; broadcast or banded;
- Foliar application as sprays;
- Soaking seed in Zinc solutions or dusting seed with Zinc Powder;
- Dipping roots of transplanted crops in solutions or suspension of Zinc salts;
- Swabbing foliage or pruning wounds with Zn paste or solution;
- Pushing galvanized nails or pieces of metallic Zn into tree trunks.

Among the various methods listed above, soil treatment and foliar sprays are most commonly used.

Soil Application

This is usually to be made as a pre-plant application by broadcast, drilling or band placement as recommended. Application rates are generally lower when the fertilizer is banded/drilled as compared to broadcast.

Application of Zn to soil is the most satisfactory way to cure Zn deficiency except for crops such as citrus on alkaline soils. Zinc is applied either broadcast or placed beside and below the seed. When broadcast, Zn fertilizers should be incorporated into the soil. Surface application without mixing is inefficient since Zinc moves little from the point of placement.

- Pre-plant or pre-sowing Zn application represents the most effective time of application;

- Water-soluble Zinc sulphate can be either broadcast (followed by mixing) or banded; but it should preferably be broadcast when in granulated form;

- In case of water-soluble sources, physical state (Powder or granules) is less important, but these sources should be broadcast when in granulated form;

- Relatively less soluble sources (Zinc oxide, Zinc phosphate, Zinc carbonate) produce yield responses comparable to soluble zinc sulphate if they are broadcast and incorporated;
- Exceedingly insoluble Zn sources (Zinc frits) are generally less efficient than Zinc sulphate even if broadcast; these can be made to perform well if applied to acid soils and as fine powder:

- Efficiency of inorganic Zn carriers applied to soil seldom exceeds 2 percent under field conditions; one application can thus last for several seasons; this was evident from the high available Zinc in soil, treated once with Zinc sulphate or Zinc oxide, even after the harvest of 3 crops; duration of the residual effect increases with the level of application of Zinc carriers;

- Continuous soil application of Zn may lead to its accumulation to toxic levels; therefore, treatment with Zn should be regulated according to the crop needs and soil tests;

- Soil application, where effective, is the most desirable strategy for field crops, if a field is known to be deficient or a soil test report is available in time;
- Soil applied Zinc has a moderate residual effect;
- The efficiency of banded or soil Zinc applications can often be improved by the presence of nitrogen fertilizers, particular those that acidify the soil. Availability of indigenous soil Zinc was also increased by treatment with the acid-forming nitrogen fertilizers ammonium sulphate and ammonium nitrate.

Foliar Application

This refers to the application of a nutrient on the leaves or green area of the crop. It requires a sprayer and some knowledge regarding the preparation of the spray solution correctly.

- Foliar applications of Zinc are made to prevent Zn deficiency in growing crops;
- Zinc sprays are almost exclusively used to alleviate Zn-deficiency in fruit trees; these are generally most effective if made before the spring flush of growth;
- For field and vegetable crops the response to foliar applied Zn is generally lower than that obtained through soil treatment. Annuals foliar sprays should not replace soil fertilization and should be used only as an emergency measures;
- Foliar sprays are to be made 2-4 times at bi-weekly intervals to cure crops from Zn deficiency; they do not produce substantial residual effect and should be repeated every season.
- Neutralized Zinc sulphate is commonly employed for foliar sprays; a typical spray solution contains 0.5 percent zinc sulphate and 0.25 per cent lime; about 400 litres of spray solution/ha are generally enough to wet the leaves thoroughly; it is advantageous to add a sticker to the spray solution; zinc concentration of spray solutions are varied for different crops.
- Lime is usually added, to obtain a near - neutral solution which should be filtered in order to use only a clear solution for spray;
- Foliar applications are effective and they are used primarily for tree crops. Sprays containing upto 50 lb of zinc sulphate in 100 gal of water are usually applied at the rate of 10 to 15 lb/A of zinc to dormant orchards. Spray treatments of up to 10 lb of $ZnSO_4$ per 100 gal of water are sometimes applied directly to the foliage of growing crops, but they can be harmful. Damage to foliage can be prevented by adding half as much hydrated lime or soda ash to the solution or using less soluble materials like Zinc oxide or carbonate.
- Chelates and natural organic complexes are particularly suitable for foliar sprays when quick recovery of young seedings is needed. These Zinc sources can be used in high analysis liquid fertilizers, where their high solubility and compatibility with other components are great advantages chelates such as Zn EDTA are mobile and can be surface applied under irrigated conditions.

Seed Treatment

In some instances Zn has been applied by treating seeds with Zinc powder or solutions prior to planting. This treatment is, however, generally inadequate to cure Zn deficiency. But dipping potato seed pieces in a Zinc suspension is said to be highly satisfactory.

To take care of Zinc deficiency, 50 gm Zinc sulphate is dissolved in 100 litres of water and tubers are soaked in it for three hours. After soaking tubers are dried in the shade for 24 hours. Planting should not be done in rainy weather and irrigation should be given after 4-5 days of planting. The dip treatment of seed tubers in 2 percent Zinc Oxide prior to planting is also a suitable method to meet Zinc need of potato crop.

Root Dipping

A possible method of correcting Zinc deficiency in rice is to dip the roots of rice seedlings in a suspension of Zinc oxide (ZnO) prior to transplanting in the main field. In this case, a 2-4% suspension of ZnO is prepared and the roots of seedlings are dipped in it. Zinc deficiency has been cured successfully by dipping seedling roots of rice in a 2-4 percent Zinc oxide suspension. It has been possible to economize in Zinc use by this method. Like foliar application, root dipping does not produce a substantial residual effect and has to be repeated each season. Also, when this technique is followed, the bundles of seedlings after the treatment should not be thrown in puddle soil with water. If this is done the Zinc oxide which is loosely sticking to the roots will get washed and effectiveness of the treatment will be diluted. The dipped seedlings should be kept in the shade for sometime before transplanting, so as to allow the sticking solution on the root surface to dry.

D. Time of Zinc Application

Time of application is important because once Zn deficiency in field crop appears, a considerable damage occurs before remedial actions are taken to correct it. Time of application will be governed by Zn content of seeds, the growth stage at which Zn is required and the severity of deficiency in the soil. Generally the Zn content of seed is low and most of them are taken up during the early growth stages thus, it favours early fertilization with Zinc. It is expected that the delayed fertilization with Zinc will be inferior to the Zinc applied at planting if deficiency is severe.

- It is suggested that for high efficiency, Zinc carriers as a rule should be applied prior to planting;
- Pre-plant soil application of Zinc should be done during land preparation or planting of seeds;
- Pre-plant seed treatment with Zinc should be done before planting of seed;
- Foliar application of Zinc should be sprayed as solution after crop establishment;
- Seedling dipping should be done just before transplanting.

Conclusion

Ingeneral zinc need to apply all over Bangladesh most of the crops. In those area zinc deficiency not acute in that case after 2-3 crops as a general dose of zinc fertilizer could be applied. Specially in those area intensive cropping has been doing zinc should be applied on regular basis. Basal application of zinc fertilizer should be more effective than after establishment of the crop. Soil application would be effective than foliar application.

Table 1: Recommended rates of Zn application in crop production (BARC, Soil Publication No. 32, 1989)

Crop		Rate (Kg Zn/ha)		
		Soil fertility		
		High	Medium	Low
1.	Chickpea	–	3	5
2.	Cotton	–	3	5
3.	Cowpea	–	2	4
4.	Groundnut	–	2	4
5.	Jute	–	4	8
6.	Lentil	–	3	5
7.	Maize	–	4	6
8.	Mustard	–	2	4
9.	Pigeon Pea	–	2	4
10.	Potato	–	2	4
11.	Rice	–	2	4
12.	Sesame	–	–	4
13.	Soybean	–	2	4
14.	Sugarcane	4	4	8
15.	Sunflower	–	–	4
16.	Tobacco	–	–	4
17.	Wheat	–	4	6
18.	Winged bean	–	–	2
19.	Chilli	–	–	4
20.	Coriander	–	3	5
21.	Ginger	–	–	2
22.	Turmeric	–	–	2
23.	Banana	–	1	2
24.	Citrus	–	–	1
25.	Coconut	–	4	8

Zn not recommended for the following crops by BARC

Barley, Brinjal, Cabbage, Cauliflower, China Sak, Bati Sak, Cucumber, Footi, Garlic, Gima Kalmi, Onion, Radish, Sweet Potato, Tomato, Watermelon, Betalnut, Guava, Jackfruit, Litchi, Mango, Papaya, Pineapple, Rubber, Tea.

Note:

All over India zinc application is recommended for more than forty different crops (Example: Chilli, Arum, Onion, Garlic, Sugarcane, Sugarbeet, Rice, Citrus, Maize, Wheat, Grape, Cabbage, Cauliflower, Broccoli, Chickpea, Lentil, Watermelon, Cotton, Guava, Groundnut, Mustard, Litchi, Coffee, Orange, Potato, Cassava, Soybean, Sorghum, Radish, Pineapple, Tea, Tomato, Coconut, Sunflower, Castor, Jute, different vegetables, etc.).

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